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# Optimization of Real Time Model using Linear Programming and MATLAB

**Ashish Kumar Atri**

***Abstract*—The Reliance Corporation is a large, fully integrated petroleum company based in India. The company produces most of its oil in its own oil field. A large distribution network is used to transport the oil to the company's refineries and then to transport the petroleum products from the refineries to Reliance's distribution centres. This work represents transportation problem and addresses the transportation flow of refined & processed oil from the refineries to the company's distribution centres. The aim is to achieve the minimum cost of transportation flow, since the cost minimization directly relates to the company's profitability of which is representing operation efficiency. The transportation model is converted into linear programming problem and is solved using MATLAB software. The models were studied based on a real time data model and as example of transportation flow of oil from various refineries to various distribution centres.***

***Keywords*—Transportation, Linear Programming, MATLAB, OIL Refinery.**

## I. INTRODUCTION

Linear programming is used for optimization of a function (maximization or minimization) of variables known as *objective function*, subject to set of linear equalities or inequalities known as *constraints*. The objective function may be used to define profit, cost, production capacity or any other measure of effectiveness, which is to be obtained in the best possible or optimal manner. The constraints may be imposed by different sources such as market demand, production processes and equipment, storage capacity; raw material availability etc. Linearity is a mathematical expression in which variables do not have powers.

All organizations have men at their disposal, also machines, material and money, the supply of which may be fairly limited. If the supply of these resources were infinite, there would be no need for management tool like linear programming at all. As the quantity of resources supplied is limited, the management needs to find the best allocation of its resources in order to maximize their profit or minimize the loss or utilize the production capacity to maximum extent.

## II. METHEDOLOGY

The procedure used for solving this problem by Linear programming approach is explained with the help of an example.

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***Correspondence Author(s)**
**Ashish Kumar Atri**, Department of Mechanical Engineering, Vellore Institute of Technology, Vellore, India.



Consider the table below:

**Table 1: Table for Linear Programming Problem**

| Supply from | Cost per unit | | | Supply |
|---|---|---|---|---|
| | P | Q | R | |
| M1 | a | b | c | S1 |
| M2 | d | e | f | S2 |
| M3 | g | h | i | S3 |
| Demand | D1 | D2 | D3 | D1+D2+D3=S1+S2+S3 |

It is required to determine how much the commodity must be transported from each supply center to each distribution center so that the total transportation cost is minimized.

***Step 1:***

From the study of the situation find the key decision to be made. In this given situation key decision is to decide the amount of commodity that must be transported from supply centres to distribution centres such that the transportation cost is minimized.

***Step 2:***

Assume symbols for variable quantities noticed in step 1. Let the amounts of commodities be $X_{11}, X_{12}, X_{13}, X_{21}, \ldots X_{33}$.

***Step 3:***

Express the feasible alternatives mathematically in terms of variables. Feasible alternatives are those which are physically and economically possible. In this given situation, $X_{11}, X_{12} \ldots X_{33} >= 0$ since negative commodity to be transported has no meaning and is not feasible.

***Step 4:***

Mention the *objective* quantitatively and express it as a linear function of variables. In the present situation, objective is to maximize profit. i.e. minimize

$Z = aX_{11}+bX_{12}+cX_{13}+dX_{21}+eX_{22}+fX_{23}+gX_{31}+hX_{32}+iX_{33}$

***Step 5:***

Put into words the *constraints*. These occur generally because of limit on availability or demands. Express these constraints in terms of variables, which in this case are on supply and demand for each centre.

$X_{11}+X_{12}+X_{13}<=S1$

Similarly $X_{11}+X_{21}+X_{31}<=D1$

And so on….



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***a. Real Data for the project***

We have taken the data of Reliance corporation which is a fully integrated petroleum company based in India. The company produces oil in its own occupied oil fields. A large distribution network is used to transport the oil to the company's refineries and then to transport the petroleum products from the refineries to Reliance's distribution centres. For this project, we have taken the data for all the company's refineries and its distribution centres which is given below:

**Supply data for each Refinery:-**

1.) Mumbai (HPCL) = 100 million barrels
2.) Mumbai (BPCL) = 60 million barrels
3.) Jamnagar = 80 million barrels
4.) Deogarh = 80 million barrels
5.) Koyali = 60 million barrels
6.) Vadinar = 70 million barrels

**Demand data for each distribution centre:-**

1.) Panvel = 100 million barrels
2.) Thane = 80 million barrels
3.) Surat = 80 million barrels
4.) Raigarh = 100 million barrels
5.) Pune= 40 million barrels
6.) Vadodara = 50 million barrels

**Distribution centers⟶**

**Table 2: Cost data for shipping oil to a distribution center**

| Refinery | Panvel | Thane | Surat | Raigarh | Pune | Vadodara | Supply |
|---|---|---|---|---|---|---|---|
| Mumbai (HP) | 6.5 | 5.5 | 6 | 8 | 5 | 6 | 100 |
| Mumbai (BP) | 7 | 5 | 4 | 7 | 6 | 7 | 60 |
| Jamnagar | 7 | 8 | 4 | 3 | 5 | 4 | 80 |
| Deogarh | 8 | 6 | 3 | 2 | 4 | 3 | 80 |
| Koyali | 5 | 4 | 3 | 6 | 4 | 5 | 60 |
| Vadinar | 4 | 3 | 1 | 5 | 6 | 2 | 70 |
| Demand | 100 | 80 | 80 | 100 | 40 | 50 | 450 |

Now let us assume some variables:

$X_{11}$= oil from Mumbai (HP) to Panvel
$X_{12}$= oil from Mumbai (HP) to Thane
$X_{13}$= oil from Mumbai (HP) to Surat
$X_{14}$= oil form Mumbai (HP) to Raigarh
$X_{15}$= oil from Mumbai (HP) to Pune
$X_{16}$= oil from Mumbai (HP) to Vadodara

$X_{21}$= oil from Mumbai (BP) to Panvel
$X_{22}$= oil form Mumbai (BP) to Thane
$X_{23}$= oil from Mumbai (BP) to Surat
$X_{24}$= oil from Mumbai (BP) to Raigarh
$X_{25}$= oil from Mumbai (BP) to Pune
$X_{26}$= oil from Mumbai (BP) to Vadodara

$X_{31}$= oil from Jamnagar to Panvel
$X_{32}$= oil from Jamnagar to Thane
$X_{33}$= oil from Jamnagar to Surat
$X_{34}$= oil from Jamnagar to Raigarh
$X_{35}$= oil from Jamnagar to Pune
$X_{36}$= oil from Jamnagar to Vadodara

$X_{41}$= oil from Deogarh to Panvel
$X_{42}$= oil from Deogarh to Thane
$X_{43}$= oil from Deogarh to Surat
$X_{44}$= oil from Deogarh to Raigarh
$X_{45}$= oil from Deogarh to Pune
$X_{46}$= oil from Deogarh to Vadodara

$X_{51}$= oil from Koyali to Panvel
$X_{52}$= oil from Koyali to Thane
$X_{53}$= oil from Koyali to Surat
$X_{54}$= oil from Koyali to Raigarh
$X_{55}$= oil from Koyali to Pune
$X_{56}$= oil from Koyali to Vadodara

$X_{61}$= oil from Vadinar to Panvel
$X_{62}$= oil from Vadinar to Thane
$X_{63}$= oil from Vadinar to Surat
$X_{64}$= oil from Vadinar to Raigarh
$X_{65}$= oil from Vadinar to Pune
$X_{66}$= oil from Vadinar to Vadodara

So the objective function based on the cost matrix is as follows:

$$\begin{aligned} Z = {} & 6.5X_{11}+5.5X_{12}+6X_{13}+8X_{14}+5X_{15}+6X_{16}+ \\ & 7X_{21}+5X_{22}+4X_{23}+7X_{24}+6X_{25}+7X_{26}+ \\ & 7X_{31}+8X_{32}+4X_{33}+3X_{34}+5X_{35}+4X_{36}+ \\ & 8X_{41}+6X_{42}+3X_{43}+2X_{44}+4X_{45}+3X_{46}+ \\ & 5X_{51}+4X_{52}+3X_{53}+6X_{54}+4X_{55}+5X_{56}+ \\ & 4X_{61}+3X_{62}+1X_{63}+5X_{64}+6X_{65}+2X_{66} \end{aligned}$$

The constraints, to which the objective function is subjected to, are formulated based on supply data and demand data. They are as follows:

1.) $j=(1-n);\ \sum X_{ij}=S_i \quad ( i = 1,2,3..... )$
i.e.
a.) $X_{11}+X_{12}+X_{13}+X_{14}+X_{15}+X_{16}= 100$
b.) $X_{21}+X_{22}+X_{23}+X_{24}+X_{25}+X_{26}= 60$
c.) $X_{31}+X_{32}+X_{33}+X_{34}+X_{35}+X_{36}= 80$
d.) $X_{41}+X_{42}+X_{43}+X_{44}+X_{45}+X_{46}= 80$
e.) $X_{51}+X_{52}+X_{53}+X_{54}+X_{55}+X_{56}= 60$
f.) $X_{61}+X_{62}+X_{63}+X_{64}+X_{65}+X_{66}= 70$

2.) $i=(1-n);\ \sum X_{ij}=D_j \quad (j = 1,2,3..... )$
i.e.
a.) $X_{11}+X_{21}+X_{31}+X_{41}+X_{51}+X_{61} = 100$
b.) $X_{12}+X_{22}+X_{32}+X_{42}+X_{52}+X_{62}= 80$
c.) $X_{13}+X_{23}+X_{33}+X_{43}+X_{53}+X_{63}= 80$
d.) $X_{14}+X_{24}+X_{34}+X_{44}+X_{54}+X_{64}= 100$
e.) $X_{15}+X_{25}+X_{35}+X_{45}+X_{55}+X_{65}= 40$
f.) $X_{16}+X_{26}+X_{36}+X_{46}+X_{56}+X_{66}= 50$

3.) $X_{1,j} >=0$

## III. SOLUTION

Once the objective function is formed, and all the constraints, to which the objective function is subjected to, are formed, the problem set up is complete. This shows that the transportation problem has been transformed into Linear Programming problem and is ready for solution. Following the problem set up, the equations are solved in order to get the results which include the amount of oil to be transported from refinery to distribution centre which will give us the minimum transportation cost.



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There are many ways to solve an LPP, such as graphical method, SIMPLEX method, etc. But due to the relative complexity of the problem, we will solve the equations in MATLAB software. A MATLAB code is prepared according to the formulated objective function and constraints. This will be run in MATLAB software which will give us the desired results through successive iterations and computations.

The MATLAB output for the Oil Company transportation problem:

OBJECTIVE FUNCTION VALUE
MINIMUM COST
fval = 1.7000e+003 = $1700 million

| Variable | Barrel load annually (millions) |
|---|---|
| $X_{11}$ | 47.9834 |
| $X_{12}$ | 12.0166 |
| $X_{13}$ | 0.0000 |
| $X_{14}$ | 0.0000 |
| $X_{15}$ | 40.0000 |
| $X_{16}$ | 0.0000 |
| $X_{21}$ | 0.0000 |
| $X_{22}$ | 60.0000 |
| $X_{23}$ | 0.0000 |
| $X_{24}$ | 0.0000 |
| $X_{25}$ | 0.0000 |
| $X_{26}$ | 0.0000 |
| $X_{31}$ | 0.0000 |
| $X_{32}$ | 0.0000 |
| $X_{33}$ | 5.9092 |
| $X_{34}$ | 51.6432 |
| $X_{35}$ | 0.0000 |
| $X_{36}$ | 22.4476 |
| $X_{41}$ | 0.0000 |
| $X_{42}$ | 0.0000 |
| $X_{43}$ | 4.0908 |
| $X_{44}$ | 48.3568 |
| $X_{45}$ | 0.0000 |
| $X_{46}$ | 27.5524 |
| $X_{51}$ | 52.0166 |
| $X_{52}$ | 7.9834 |
| $X_{53}$ | 0.0000 |
| $X_{54}$ | 0.0000 |
| $X_{55}$ | 0.0000 |
| $X_{56}$ | 0.0000 |
| $X_{61}$ | 0.0000 |
| $X_{62}$ | 0.0000 |
| $X_{63}$ | 70.0000 |
| $X_{64}$ | 0.0000 |
| $X_{65}$ | 0.0000 |
| $X_{66}$ | 0.0000 |

## IV. RESULTS AND DISCUSSION

After successful iterations using MATLAB, the optimal solution of $1700 million is computed. (To solve this LP by hand would have required computations for at least six simplex tables).

The $1700 million represents the minimum annual costs for the Oil Company Reliance from six refineries to six distribution centers. We can use the values in the Barrel load column to assign values to our variables and determine the barrel haul transportation. For variable $X_{11}$, which is Mumbai (HP) to Panvel, the value- Barrel load annually – is 48 million approx. For variable $X_{22}$, which is Mumbai (BP) to Thane, the value is 60 million; and from $X_{31}$, Jamnagar to Panvel, the value is zero, so no barrels will be hauled from Jamnagar to Panvel, and so on.

**Distribution centers⟶**

**Table 3: Reliance Company barrel load haul (approximated)**

| Refinery | Panvel | Thane | Surat | Raigarh | Pune | Vadodara | Supply |
|---|---|---|---|---|---|---|---|
| Mumbai (HP) | 48 | 12 | 0 | 0 | 40 | 0 | 100 |
| Mumbai (BP) | 0 | 60 | 0 | 0 | 0 | 0 | 60 |
| Jamnagar | 0 | 0 | 6 | 52 | 0 | 22 | 80 |
| Deogarh | 0 | 0 | 4 | 48 | 0 | 28 | 80 |
| Koyali | 52 | 8 | 0 | 0 | 0 | 0 | 60 |
| Vadinar | 0 | 0 | 70 | 0 | 0 | 0 | 70 |
| Demand | 100 | 80 | 80 | 100 | 40 | 50 | 450 |

**Table 4: Annual shipping cost to a distribution center**

| Barrel load per day ( Millions) | Cost per barrel (in $) | Total cost ( Millions of $) |
|---|---|---|
| 48 | 6.5 | 312 |
| 12 | 5.5 | 66 |
| 40 | 5 | 200 |
| 60 | 5 | 300 |
| 6 | 4 | 24 |
| 52 | 3 | 156 |
| 22 | 4 | 88 |
| 4 | 3 | 12 |
| 48 | 2 | 96 |
| 28 | 3 | 84 |
| 52 | 5 | 260 |
| 8 | 4 | 32 |
| 70 | 1 | 70 |
| | Total = | 1700 |

## V. CONCLUSION

In this project the real time data was taken from Reliance Corporation, which is a fully integrated petroleum company based in India. The transportation problem was constructed on the oil supply data from the company's refineries and the demand of its distribution centres. This transportation model is then converted into Linear Programming problem and subsequently also the objective function and all the constraints were formulated. The equations are solved so as to minimize the transportation cost for the transportation of oil from the refineries to distribution centres.

From a viewpoint of finance, the barrel distribution shown in Table 3 is the best for transportation from refineries to distribution centers. This distribution computed in this paper can save the company about millions of dollars annually. However, decision of the management must consider a wide variety of factors. Furthermore, if any more ways can be found to reduce some of the costs in Table 4, this might change the financial evaluation by management substantially.


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The management can also consider whether there are any new cost trends or trends in the marketplace that might incur change in the future.

## APPENDIX

Matlab Code

**CODE 1**

```
function Simplex Using MATLAB()
clc
format compact
format rational
A =[1 1 1 1 1 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 100;0 0 0 0 0 0 1 1 1 1 1 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 60;  0 0 0 0 0 0 0 0 0 0 0 0 1 1 1 1 1 1 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 80; 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
0 0 1 1 1 1 1 1 0 0 0 0 0 0 0 0 0 0 0 0 80; 0 0 0 0 0 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 1 1 1 1 1 1 0 0 0 0 0 0 60; 0 0 0 0 0 0
0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 1 1 1 1 1 70; 1
0 0 0 0 0 1 0 0 0 0 0 1 0 0 0 0 0 1 0 0 0 0 0 1 0 0 0 0 0 1 0 0 0
0 0 100; 0 1 0 0 0 0 0 1 0 0 0 0 0 1 0 0 0 0 0 1 0 0 0 0 0 1 0 0 0
0 0 1 0 0 0 0 80; 0 0 1 0 0 0 0 0 1 0 0 0 0 0 1 0 0 0 0 0 1 0 0 0
0 0 1 0 0 0 0 0 1 0 0 0 80; 0 0 0 1 0 0 0 0 0 1 0 0 0 0 0 1 0 0 0
0 0 1 0 0 0 0 0 1 0 0 0 0 0 1 0 0 100; 0 0 0 0 1 0 0 0 0 0 1 0 0 0
0 0 1 0 0 0 0 0 1 0 0 0 0 0 1 0 0 0 0 0 1 0 40;0 0 0 0 0 1 0 0 0 0
0 1 0 0 0 0 0 1 0 0 0 0 0 1 0 0 0 0 0 1 0 0 0 0 0 1 50;    6.5 5.5
6 8 5 6 7 5 4 7 6 7 7 8 4 3 5 4 8 6 3 2 4 3 5 4 3 6 4 5 4 3 1 5 6
2 0];

[n m]= size(A);
fprintf('This is Table 1 - note the canonical form\n'),disp(A);
for iloop = 1:m
   [val ebv] = max(A(n,:));
   if val > 1
      fprintf('\nEntering Basic Variable Column  :
'),disp(ebv);
      lbv = LBV(A,ebv);
      fprintf('\nLeaving Basic Variable (Pivot Row) :
'),disp(lbv)
   else
      fprintf('\nNo further iterations possible')
      fprintf('\nYou may have the solution')
      fprintf('\nFinal table :')
      format short g;
      fprintf('\n-------------\n'),disp(A);
      break;
   end
   if lbv > 0
      A = RowOperations(A,ebv,lbv);
      textstr = strcat('Simplex Table :',num2str(iloop+1));
      disp(textstr);
      disp(A);
    end
end

function ret = LBV(A,i)
% i is the entering basic variable column
[n m] = size(A);
j =1;  max = 1000;
for k = 1:n
   if A(k,i) > 0
      row = A(k,m)/A(k,i);
      if row < max
         max = row;  j = k;
      end
   end
 end

if j == 0
   fprintf('Not possible to evaluate EBV ')
   return;
end
ret = j;
function ret = RowOperations(A,i,j)
% i is the EBV column
% j is the pivot row
[n m] = size(A);
A(j,:) = A(j,:)/A(j,i);
for k = 1: n
   if (k ~= j)
      A(k,:) = A(k,:) - A(k,i)*A(j,:);
   end
end
ret = A;
```

**CODE 2**

```
f = [6.5; 5.5; 6; 8; 5; 6; 7; 5; 4; 7; 6; 7; 7; 8; 4; 3; 5; 4; 8; 6; 3;
2; 4; 3; 5; 4; 3; 6; 4; 5; 4; 3; 1; 5; 6; 2];

A= [1 1 1 1 1 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
   0 0 0 0 0 0 1 1 1 1 1 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
   0 0 0 0 0 0 0 0 0 0 0 0 1 1 1 1 1 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
   0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 1 1 1 1 1 0 0 0 0 0 0 0 0 0 0 0 0
   0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 1 1 1 1 1 0 0 0 0 0 0
   0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 1 1 1 1 1
   1 0 0 0 0 0 1 0 0 0 0 0 1 0 0 0 0 0 1 0 0 0 0 0 1 0 0 0 0 0 1 0 0 0 0 0
   0 1 0 0 0 0 0 1 0 0 0 0 0 1 0 0 0 0 0 1 0 0 0 0 0 1 0 0 0 0 0 1 0 0 0 0
   0 0 1 0 0 0 0 0 1 0 0 0 0 0 1 0 0 0 0 0 1 0 0 0 0 0 1 0 0 0 0 0 1 0 0 0
   0 0 0 1 0 0 0 0 0 1 0 0 0 0 0 1 0 0 0 0 0 1 0 0 0 0 0 1 0 0 0 0 0 1 0 0
   0 0 0 0 1 0 0 0 0 0 1 0 0 0 0 0 1 0 0 0 0 0 1 0 0 0 0 0 1 0 0 0 0 0 1 0
   0 0 0 0 0 1 0 0 0 0 0 1 0 0 0 0 0 1 0 0 0 0 0 1 0 0 0 0 0 1 0 0 0 0 0 1 ];
 b=[100;60;80;80;60;70;100;80;80;100;40;50];
   [x,fval] = linprog(f,A,b);
```

**SUCCESS CODE**

```
f = [6.5; 5.5; 6; 8; 5; 6; 7; 5; 4; 7; 6; 7; 7; 8; 4; 3; 5; 4; 8; 6; 3; 2; 4; 3; 5; 4; 3;
6; 4; 5; 4; 3; 1; 5; 6; 2];

A= [1 1 1 1 1 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
   0 0 0 0 0 0 1 1 1 1 1 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
   0 0 0 0 0 0 0 0 0 0 0 0 1 1 1 1 1 1 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
   0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 1 1 1 1 1 0 0 0 0 0 0 0 0 0 0 0 0
   0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 1 1 1 1 1 0 0 0 0 0 0
 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 1 1 1 1 1 1
```


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```
 0 0 0 0 0 1 0 0 0 0 0 1 0 0 0 0 0 1 0 0 0 0 0 1 0 0 0 0 0 1 0 0 0 0 0
 0 1 0 0 0 0 0 1 0 0 0 0 0 1 0 0 0 0 0 1 0 0 0 0 0 1 0 0 0 0 0 1 0 0 0 0
 0 0 1 0 0 0 0 0 1 0 0 0 0 0 1 0 0 0 0 0 1 0 0 0 0 0 1 0 0 0 0 0 1 0 0 0
 0 0 0 1 0 0 0 0 0 1 0 0 0 0 0 1 0 0 0 0 0 1 0 0 0 0 0 1 0 0 0 0 0 1 0 0
 0 0 0 0 1 0 0 0 0 0 1 0 0 0 0 0 1 0 0 0 0 0 1 0 0 0 0 0 1 0 0 0 0 0 1 0
 0 0 0 0 0 1 0 0 0 0 0 1 0 0 0 0 0 1 0 0 0 0 0 1 0 0 0 0 0 1 0 0 0 0 0 1 ];
b=[100;60;80;80;60;70;100;80;80;100;40;50];
lb = zeros(size(A));
[x,fval,exit_flag] = linprog(f,A,b,A,b,lb,100)
```

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**AUTHOR PROFILE**

**Ashish Kumar Atri** has completed B.tech Mechanical engineering from Vellore institute of technology. His research interests are Thermal Systems, Automotive Systems, Operations research, Design of machines.