M.Sc. MATHEMATICS LAB MANUAL

4th Semester

Prepared By

Pure & Applied Science Dept.

Mathematics

MIDNAPORE CITY COLLEGE

MIDNAPORE CITY COLLEGE

Department of Pure & Applied Sciences
Subject: M.Sc. in Mathematics

MATLAB LABORATORY MANUAL
(Course Code: MTM 495B)

Semester: IV

INSTRUCTIONS TO STUDENTS

- Before entering the lab, the student should carry the following things (MANDATORY)
    1. Identity card issued by the college.
    2. Class notes
    3. Lab observation book
    4. Lab Manual
    5. Lab Record
- Student must sign in and sign out in the register provided when attending the lab session without fail.
- Come to the laboratory in time. Students, who are late more than 10 min., will not be allowed to attend the lab.
- Students need to maintain 80% attendance in lab if not a strict action will be taken.
- All students must follow a Dress Code while in the laboratory.
- Foods, drinks are NOT allowed.
- All bags must be left at the indicated place.
- Refer to the lab staff if you need any help in using the lab.
- Respect the laboratory and its other users.
- Workspace must be kept clean and tidy after experiment is completed.
- Read the Manual carefully before coming to the laboratory and be sure about what you are supposed to do.
- Do the experiments as per the instructions given in the manual.
- Copy all the programs to observation which are taught in class before attending the lab session.
- Students are not supposed to use floppy disks, pen drives without permission of lab- in charge.
- Lab records need to be submitted on or before the date of submission.

OVERVIEW

MATLAB (MATrix LABoratory) is a fourth-generation high-level programming language and interactive environment for numerical computation, visualization and programming.

MATLAB is developed by MathWorks.

It allows matrix manipulations; plotting of functions and data; implementation of algorithms; creation of user interfaces; interfacing with programs written in other languages, including C, C++, Java, and FORTRAN; analyze data; develop algorithms; and create models and applications.

It has numerous built-in commands and math functions that help you in mathematical calculations, generating plots, and performing numerical methods.

MATLAB'S POWER OF COMPUTATIONAL MATHEMATICS

MATLAB is used in every facet of computational mathematics. Following are some commonly used mathematical calculations where it is used most commonly:

- Dealing with Matrices and Arrays
- 2-D and 3-D Plotting and graphics
- Linear Algebra
- Algebraic Equations
- Non-linear Functions
- Statistics
- Data Analysis
- Calculus and Differential Equations
- Numerical Calculations
- Integration
- Transforms
- Curve Fitting
- Various other special functions

FEATURES OF MATLAB

Following are the basic features of MATLAB:

- It is a high-level language for numerical computation, visualization and application development.
- It also provides an interactive environment for iterative exploration, design and problem solving.
- It provides vast library of mathematical functions for linear algebra, statistics, Fourier analysis, filtering, optimization, numerical integration and solving ordinary differential equations.
- It provides built-in graphics for visualizing data and tools for creating custom plots.
- MATLAB's programming interface gives development tools for improving code quality, maintainability, and maximizing performance.
- It provides tools for building applications with custom graphical interfaces.
- It provides functions for integrating MATLAB based algorithms with external applications and languages such as C, Java, .NET and Microsoft Excel.

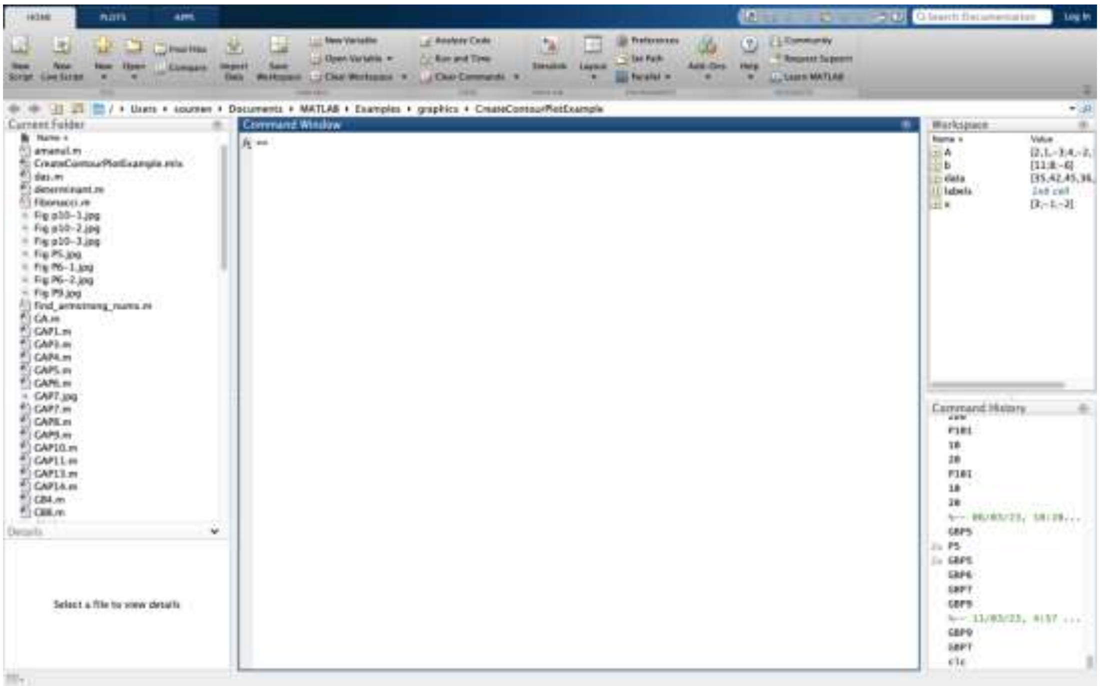
USES OF MATLAB

MATLAB is widely used as a computational tool in science and engineering encompassing the fields of physics, chemistry, math and all engineering streams. It is used in a range of applications including:

- Signal processing and Communications
- Image and video Processing
- Control systems
- Test and measurement
- Computational finance
- Computational biology

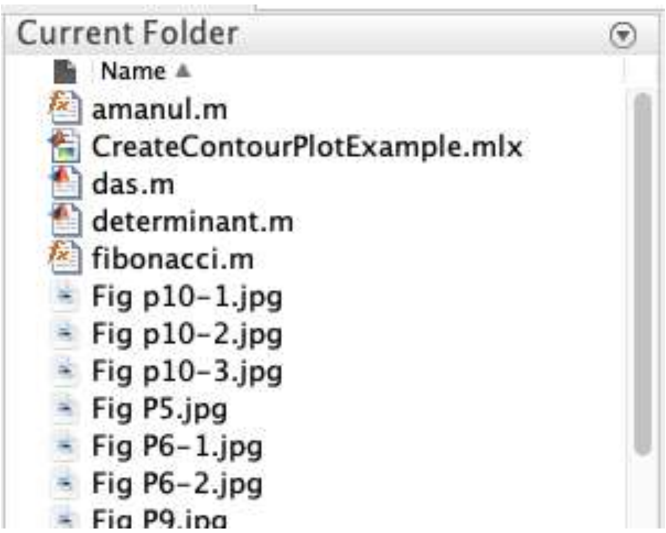
UNDERSTANDING THE MATLAB ENVIRONMENT

MATLAB development IDE can be launched from the icon created on the desktop. The main working window in MATLAB is called the desktop. When MATLAB is started, the desktop appears in its default layout:

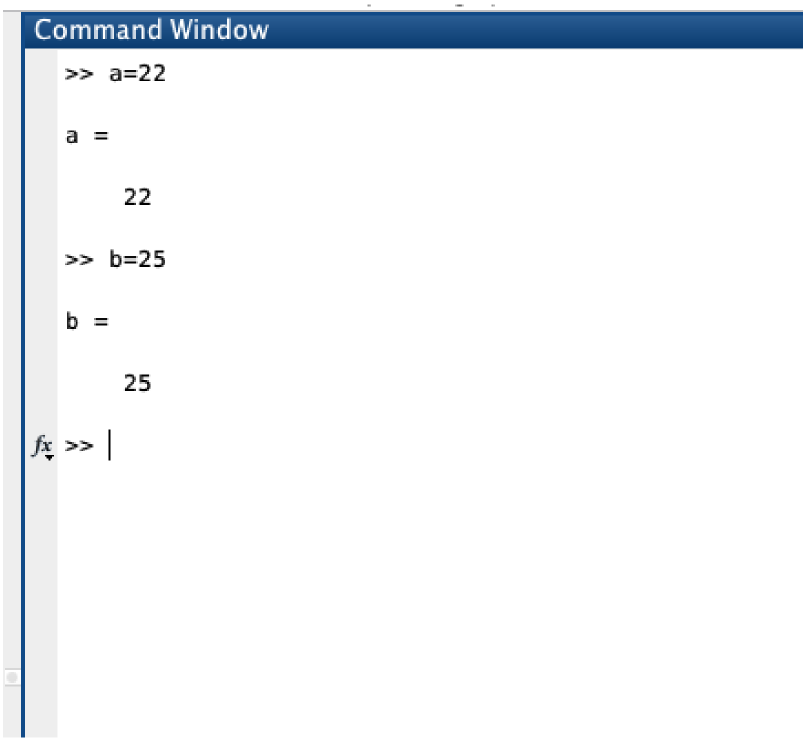


The desktop has the following panels:

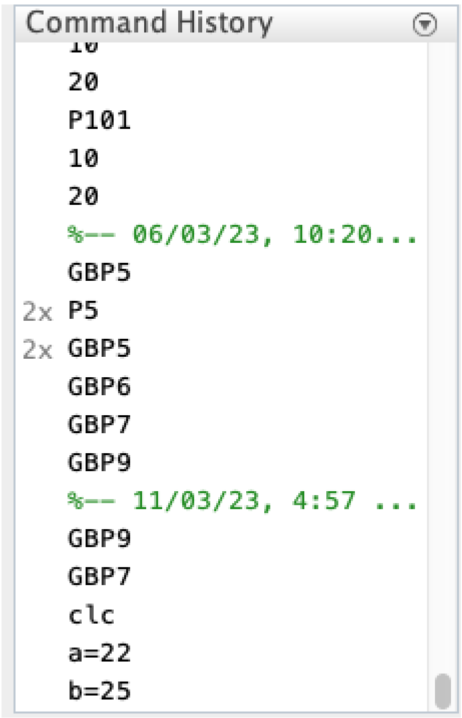
Current Folder - This panel allows you to access the project folders and files.



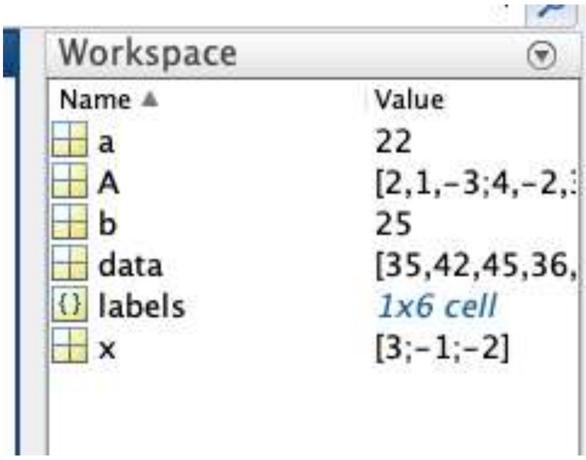
Command Window - This is the main area where commands can be entered at the command line. It is indicated by the command prompt (>>).



Command History - This panel shows or rerun commands that are entered at the command line.



Workspace - The workspace shows all the variables created and/or imported from files.



OVERVIEW

LINGO is a powerful software tool widely used for solving optimization problems. It stands for "Linear and Generalized Optimization" and is developed by LINDO Systems, Inc. LINGO provides a comprehensive environment for formulating, solving, and analyzing a wide range of linear, nonlinear, integer, and stochastic optimization models.

One of the key features of LINGO is its user-friendly modeling language, which allows users to express optimization problems in a natural and intuitive manner. The modeling language supports a wide range of mathematical expressions, including linear and nonlinear objective functions, constraints, and decision variables. Users can define their optimization models using algebraic expressions, logical conditions, and set notations, making it easier to translate real-world problems into mathematical formulations.

LINGO offers a variety of solvers to handle different types of optimization problems. For linear programming (LP) and mixed-integer programming (MIP) models, LINGO includes the powerful simplex and branch-and-bound algorithms. Nonlinear programming (NLP) problems can be solved using LINGO's advanced global optimization solver or by employing local search methods. Stochastic programming models are handled using LINGO's stochastic solver, which incorporates techniques such as Monte Carlo simulation and scenario generation.

In addition to solving optimization models, LINGO provides a range of tools for model analysis and post-optimality analysis. It offers comprehensive reports and summary statistics to help users understand the results of their optimization runs. Sensitivity analysis capabilities allow users to explore the impact of changes in model parameters, such as objective coefficients and constraint bounds, on the optimal solution. LINGO also supports data import and export from various formats, making it easy to integrate with other software tools.

LINGO is widely used in various industries and academic fields where optimization problems arise, including operations research, supply chain management, finance, engineering, and logistics. It has a reputation for its robustness, efficiency, and versatility in handling complex optimization problems. The software's user-friendly interface and extensive documentation make it accessible to both beginners and experienced optimization practitioners.

Overall, LINGO is a comprehensive and powerful software tool for solving optimization problems. Its modeling language, solvers, and analysis capabilities make it an essential resource for professionals and researchers seeking to optimize their decision-making processes and improve efficiency in a wide range of applications.

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	(e) What is the probability that an arrival has to wait more than 10 minutes before the phone is free? (f) Estimate the fraction of a day that the phone will be in use (or busy).	
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7.	Write a program in MATLAB to solve the following LPP using Revised simplex method $\text{Min } z = x_1 + x_2$ $\text{subject to, } x_1 + 2x_2 \geq 7$ $4x_1 + x_2 \geq 6$ $x_1, x_2 \geq 0$	07
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26.	Write a program in LINGO to solve the following LPP using simplex method $\text{Max } z = 2x_1 + 3x_2 - x_3$ $\text{subject to, } 2x_1 + 5x_2 - x_3 \leq 5$ $x_1 + x_2 + 2x_3 = 6$ $2x_1 - x_2 + 3x_3 = 7$ $x_1, x_2, x_3 \geq 0$	28
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28.	Write a program in LINGO to solve the following QPP using Wolfe's modified simplex method $\text{Max } z = 2x_1 + 3x_2 - x_1^2$ $\text{Subject to, } x_1 + 2x_2 \leq 4$ $x_1, x_2 \geq 0$	30
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33.	Write a program in LINGO to solve the following problem of Inventory. The demand for an item is deterministic and constant over time and is equal to	35-36

	600 units per year. The unit cost of the item is Rs. 50.00 while the cost of placing an order is Rs. 100.00. The inventory carrying cost is 20% of the item and the shortage cost per month is Rs. 1.Find the optimal ordering quantity. If shortages are not allowed, what would be the loss of the company ?	
34.	Write a program in LINGO to solve the following problem of Inventory. The demand for an item in a company is 18000 units per year. The company can produce the item at a rate of 3000 per month. The cost of one set-up is Rs. 500 and the holding cost of one unit per month is Rs. 0.15. The shortage cost of one unit is Rs. 20 per month. Determine the optimum manufacturing quantity. Also determine the manufacturing time and the time between setup.	37-38
35.	Write a program in MATLAB to solve the following QPP using Wolfe's modified simplex method Max $z = 18x_1 + 3x_2 - 0.001x_1^2 - 0.005x_2^2 - 100$ Subject to, $2x_1 + 3x_2 \leq 2500$ $x_1 + 2x_2 \leq 1500$ $x_1, x_2 \geq 0$	39

Programming 1: Write a program in MATLAB to solve the following LPP using simplex method.

$$\text{Min } z = -3x_1 + 4x_2$$
$$\text{Subject to, } x_1 + x_2 \le 8$$
$$2x_1 + 5x_2 \le 22$$
$$x_2 \le 4$$
$$x_1, x_2 \ge 0$$

Code:

```
c=[-3,4];
A=[1,1;2,5];
b=[8;22]; Aeq=[];
beq=[];
lb=[0;0];
ub=[inf;4];
xsol = linprog(c,A,b,Aeq,beq,lb,ub);
disp(xsol);
fprintf('The optimum value is %f\n',c*xsol);
```

Input/output:

```
Optimization terminated.
    8.0000
    0.0000

The optimum value is -24.000000
```

Programming 2: Write a script in MATLAB to solve the following LPP using Revised Simplex Method.

$$\text{Max } z = x_1 + x_2$$
$$\text{Subject to, } 3x_1 + 2x_2 \leq 6$$
$$x_1 + 4x_2 \leq 4$$
$$x_1, x_2 \geq 0$$

Code:

```
c=[-1,-1];
A=[3,2;1,4];
b=[6;4];
Aeq=[];
beq=[];
lb=[0;0];
ub=[inf;inf];
xsol = linprog(c,A,b,Aeq,beq,lb,ub);
disp(xsol);
fprintf('The optimum value is %f\n',-c*xsol);
```

Input/output:

```
Optimization terminated.
    1.6000
    0.6000

The optimum value is 2.200000
```

Programming 3: Write a program in MATLAB to solve the following QPP using Wolfe's modified simplex method

$$\text{Max } z = 4x_1 + 6x_2 - 2x_1^2 - 2x_1x_2 - 2x_2^2$$

$$\text{Subject to, } x_1 + 2x_2 \leq 2$$

$$x_1, x_2 \geq 0$$

Code:

```
c=[-4,-6];
Q=[4,2;2,4];
A=[1,2];
b=[2];
Aeq=[];
beq=[];
lb=[0;0];
ub=[inf,inf];
xsol=quadprog(Q,c,A,b,Aeq,beq,lb,ub);
disp(xsol);
fprintf('The value of the objective function is %f\n',-
(c*xsol+0.5*xsol'*Q*xsol));
```

Input/output:

```
Optimization terminated.
    0.3333
    0.8333

The value of the objective function is 4.166667
```

Programming 4:

Write a program in MATLAB to solve the following Queuing theorem problem.

Arrivals at a telephone booth are considered to be Poisson with an average time of 10 minutes between one arrival and the next. The length of a phone call is assumed to be distributed exponentially with mean 3 minutes.

(a) What is the probability that a person arriving at the booth will have to wait?

(b) What is the average length of queues that form from time to time?

(c) The telephone company will install a second booth when convinced that an arrival would expect to have to wait at least 3 minute for the phone. By how much must the flow of arrivals be increased to justify a second booth?

(d) Find the average number of units in the system.

(e) What is the probability that an arrival has to wait more than 10 minutes before the phone is free?

(f) Estimate the fraction of a day that the phone will be in use (or busy).

Code:

```
lmda=input('Enter the mean arrival rate: ');
mu=input('Enter the mean service time: ');
fprintf('(a) The probablity that a person arriving at the telephone
booth will have to wait is %0.2f\n',lmda/mu);
fprintf('(b) Average length of queue that form from time to time is
%0.2f persons\n',mu/(mu-lmda));
t=input('(c) Enter expected waiting time: ');
plmda=(mu^2)*t/(1+mu*t);
fprintf(' The second booth is justified in the increase in arrival rate
%d persons per hour\n', ceil(60*(plmda-lmda)));
fprintf('(d) Average number of units in the system is %0.2f
persons\n',lmda/(mu-lmda));
fprintf('(e) Probablity that an arrival is to wait more than 10 minutes
is %0.2f\n',-(lmda/mu)*(0-exp(10*(lmda-mu))));
fprintf('(f) The fraction of a day the phone willbe in use is
%0.2f\n',lmda/mu);
```

Input/output:

Enter the mean arrival rate: 0.1
Enter the mean service time: 0.33
(a) The probablity that a person arriving at the telephone booth will have to wait is 0.30
(b) Average length of queue that form from time to time is 1.43 persons
(c) Enter expected waiting time: 3
The second booth is justified in the increase in arrival rate 4 persons per hour
(d) Average number of units in the system is 0.43 persons
(e) Probablity that an arrival is to wait more than 10 minutes is 0.03
(f) The fraction of a day the phone willbe in use is 0.30

Programming 5:

Write a program in LINGO & MATLAB to solve the following problem of Inventory.

An engineering factory consumes 5000 units of a component per year. The ordering, receiving and handling cost are Rs.300 per order while trucking cost is Rs.1200 per order, internet cost Rs. 0.06per unit per year, Deterioration and obsolence cost Rs 0.004 per year and storage cost Rs. 1000 per year for 5000 units. Calculate the economic order quantity and minimum average cost.

Code:

```
D=input('Enter the demand: ');
c3=input('Enter the total ordering cost: ');
c1=input('Enter the total holding cost: ');
fprintf('The economic order quantity is %0.2f\n',sqrt(2*c3*D/c1));
fprintf('The minimum average cost is Rs.%0.2f\n',sqrt(2*c3*c1*D));
```

Input/output:

Enter the demand: 5000
Enter the total ordering cost: 1500
Enter the total holding cost: 0.264
The economic order quantity is 7537.78
The minimum average cost is Rs.1989.97

Programming 6: ***Write a program in MATLAB to solve the following LPP using simplex method***

$$Max\ z = 2x_1 + 3x_2 - x_3$$
$$subject\ to,\ 2x_1 + 5x_2 - x_3 \leq 5$$
$$x_1 + x_2 + 2x_3 = 6$$
$$2x_1 - x_2 + 3x_3 = 7$$
$$x_1, x_2, x_3 \geq 0$$

Code:

```
c=[-2,-3,1];
A=[2,5,-1];
b=[5];
Aeq=[1,1,2;2,-1,3];
beq=[6;7];
lb=[0,0];
ub=[];
xsol=linprog(c,A,b,Aeq,beq,lb,ub);
disp(xsol);
fprintf('The optimal value is %f\n',-c*xsol);
```

Input/output:

Optimization terminated.

1.0000
1.0000
2.0000

The optimal value is 3.000000

Programming 7: ***Write a program in MATLAB to solve the following LPP using Revised simplex method***

$Min\ z = x_1 + x_2$

$subject\ to,\ x_1 + 2x_2 \geq 7$

$4x_1 + x_2 \geq 6$

$x_1, x_2 \geq 0$

Code:

```
c=[1,1];
A=[-1,-2;-4,-1];
b=[-7;-6];
Aeq=[];
beq=[];
lb=[0;0];
ub=[inf;inf];
xsol=linprog(c,A,b,Aeq,beq,lb,ub);
disp(xsol);
fprintf('The optimal value is %f\n',c*xsol);
```

Input/output:

Optimization terminated.
0.7143
3.1429

The optimal value is 3.857143

Programming 8: ***Write a program in MATLAB to solve the following QPP using Wolfe's modified simplex method***

Max $z = 2x_1 + 3x_2 - x_1^2$

Subject to, $x_1 + 2x_2 \leq 4$

$x_1, x_2 \geq 0$

Code:

```
c=[-2,-3];
Q=[2,0;0,0];
A=[1,2];
b=[4];
Aeq=[];
beq=[];
lb=[0;0];
ub=[inf;inf];
xsol=quadprog(Q,c,A,b,Aeq,beq,lb,ub);
disp(xsol);
fprintf('The value of the objective function is %f\n',-
(c*xsol+0.5*xsol'*Q*xsol));
```

Input/output:

```
Optimization terminated.
    0.2500
    1.8750

The value of the objective function is 6.062500
```

Programming 9:

Write a program in MATLAB to solve the following problems of Inventory.

A constructer has to supply 10,000 bearing per day to an auto-mobile manufacturer. He find that when he start a production run, he can produce 25,000 bearing per day .The cost of holding a bearing in stock for one year is Rs 2 and set up cost for producing run is Rs 180.How frequently should the production ?

Code:

```
k=input('Enter the production rate: ');
D=input('Enter the demand: ');
c1=input('Enter the holding cost: ');
c3=input('Enter the set up cost: ');
fprintf('The production should be made after %d
days\n',ceil(sqrt(2*c3*k/(c1*D*(k-D)))));
```

Input/output:

```
Enter the production rate: 25000
Enter the demand: 10000
Enter the holding cost: 0.005
Enter the set up cost: 180
The production should be made after 4 days
```

Programming 10: ***Write a program in MATLAB to solve the following LPP using simplex method***

$Max\ z = 3x_1 + 4x_2$

$subject\ to, x_1 + x_2 \leq 10$

$2x_1 + 3x_2 \leq 18$

$x_1 \leq 8$

$x_2 \leq 6$

$x_1, x_2 \geq 0$

Code:

```
c=[-3,-4];
A=[1,1;2,3];
b=[10;18];
Aeq=[];
beq=[];
lb=[0;0];
ub=[8;6];
xsol = linprog(c,A,b,Aeq,beq,lb,ub);
disp(xsol);
fprintf('The optimum value is %f\n',-c*xsol);
```

Input/output:

Optimization terminated.
8.0000
0.6667

The optimum value is 26.666667

Programming 11: ***Write a program in MATLAB to solve the following LPP using simplex method***

$Max\ z = 3x_1 + 5x_2$

$subject\ to, x_1 \leq 4$

$x_2 \leq 6$

$3x_1 + 2x_2 \leq 18$

$x_1, x_2 \geq 0$

Code:

```
c=[-3,-5];
A=[3,2];
b=[18];
Aeq=[];
beq=[];
lb=[0;0];
ub=[4;6];
xsol=linprog(c,A,b,Aeq,beq,lb,ub);
disp(xsol);
fprintf('The optimal value is %f\n',-c*xsol);
```

Input/output:

```
Optimization terminated.
    2.0000
    6.0000

The optimal value is 36.000000
```

Programming 12: ***Write a program in MATLAB to solve the following QPP using Wolfe's modified simplex method***

Max $z = 2x_1 + x_2 - x_1^2$

Subject to, $2x_1 + 3x_2 \leq 6$

$2x_1 + x_2 \leq 4$

$x_1, x_2 \geq 0$

Code:

```
c=[-2,-1];
Q=[2,0;0,0];
A=[2,3;2,1];
b=[6,4];
Aeq=[];
beq=[];
lb=[0;0];
ub=[inf;inf]; xsol=quadprog(Q,c,A,b,Aeq,beq,lb,ub);
disp(xsol);
fprintf('The value of the objective function is %f\n',-
(c*xsol+0.5*xsol'*Q*xsol));
```

Input/output:

Optimization terminated.
    0.6667
    1.5556

The value of the objective function is 2.444444

Programming 13:

Write a program in MATLAB to solve the following Queuing theorem problem.

In a car wash service facility information gather indicates that cars arrive for service according to a Poisson distribution with mean 5 per hour. The time for washing and cleaning for each car varies but is found to follow an exponential distribution with mean 10 minutes per car. The facility can not handle more than one car at a time and has a total of 5 parking spaces. If the parking spot is full, newly arriving cars balk to 6 services elsewhere.

(a) How many customers the manager of the facility is loosing due to the limited parking spaces?

(b) What is the expected waiting time until a car is washed?

Code:

```
N=input('Enter the capacity of the system: ');
lmda=input('Enter the mean arrival rate: ');
mu=input('Enter the mean service rate: ');
ro=lmda/mu; pN=((1-ro)*ro^N)/(1-ro^(N+1));
lmdaeff=lmda*(1-pN); fprintf('(a) The rate at which the cars balk is
%0.2f cars/hour\n',lmda-lmdaeff);
ls=ro*(1-(N+1)*ro^N+N*ro^(N+1))/((1-ro)*(1-ro^(N+1)));
fprintf('(b) The expected waiting time until a car is washed is given
by %0.2f hours\n',ls/lmdaeff);
```

Input/output:

```
Enter the capacity of the system: 5
Enter the mean arrival rate: 5
Enter the mean service rate: 6
(a) The rate at which the cars balk is 0.50 cars/hour
(b) The expected waiting time until a car is washed is given by 0.44
hours
```

Programming 14:

Write a program in MATLAB to solve the following problem of Inventory.
The demand for an item is deterministic and constant over time and is equal to 600 units per year. The unit cost of the item is Rs. 50.00 while the cost of placing an order is Rs. 100.00. The inventory carrying cost is 20% of the item and the shortage cost per month is Rs. 1. Find the optimal ordering quantity. If shortages are not allowed, what would be the loss of the company ?

Code:

```
D=input('Enter the demand: ');
c1=input('Enter the holding cost: ');
c2=input('Enter the shortage cost: ');
c3=input('Enter the ordering cost: ');
fprintf('The optimal order quantity is %0.2f
units\n',sqrt(2*c3*(c1+c2)*D/(c1*c2)));
costws=sqrt(2*c1*c2*c3*D/(c1+c2));
costwns=sqrt(2*c1*c3*D);
fprintf('If shortages are not allowed, the loss of the company will be
Rs.%0.2f\n',costwns-costws);
```

Input/output:

```
Enter the demand: 600
Enter the holding cost: 10
Enter the shortage cost: 12
Enter the ordering cost: 100
The optimal order quantity is 148.32 units
If shortages are not allowed, the loss of the company will be
Rs.286.41
```

Programming 15: ***Write a program in MATLAB to solve the following LPP using simplex method***

$Max\ z = 5x_1 - x_2 + 3x_3$

$subject\ to,\ 2x_1 + 2x_2 - x_3 \geq 2$

$3x_1 - 4x_2 \leq 3$

$x_2 + 3x_3 \leq 5$

$x_1, x_2, x_3 \geq 0$

Code:

```
c=[-5,1,-3];
A=[-2,-2,1;3,-4,0;0,1,3];
b=[-2;3;5];
Aeq=[];
beq=[];
lb=[0;0;0];
ub=[inf;inf;inf];
xsol = linprog(c,A,b,Aeq,beq,lb,ub);
disp(xsol);
fprintf('The optimum value is %f\n',-c*xsol);
```

Input/output:

```
Optimization terminated.
    7.6667
    5.0000
    0.0000

The optimum value is 33.333333
```

Programming 16: ***Write a program in MATLAB to solve the following LPP using Revised simplex method***

$$\text{Max } z = 10x_1 + 9x_2$$

$$\text{subject to}, 8x_1 + 15x_2 \geq 10$$

$$10x_1 + 6x_2 \leq 10$$

$$6x_1 + 24x_2 \leq 12$$

$$x_1, x_2 \geq 0$$

Code:

```
c=[-10,-9];
A=[-8,-15;10,6;6,24];
b=[-10;10;12];
Aeq=[];
beq=[];
lb=[0;0];
ub=[inf;inf];
xsol=linprog(c,A,b,Aeq,beq,lb,ub);
disp(xsol);
fprintf('The optimal value is %f\n',-c*xsol);
```

Input/output:

```
Optimization terminated.
    0.8235
    0.2941

The optimal value is 10.882353
```

Programming 17: ***Write a program in MATLAB to solve the following QPP using Wolfe's modified simplex method***

Max $z = 18x_1 + 3x_2 - 0.001x_1^2 - 0.005x_2^2 - 100$

Subject to, $2x_1 + 3x_2 \leq 2500$

$x_1 + 2x_2 \leq 1500$

$x_1, x_2 \geq 0$

Code:

```
c=[-18,-3];
Q=[0.002,0;0,0.01];
A=[2,3;1,2];
b=[2500;1500];
Aeq=[];
beq=[];
lb=[0;0];
ub=[inf;inf];
xsol=quadprog(Q,c,A,b,Aeq,beq,lb,ub);
disp(xsol);
fprintf('The value of the objective function is %f\n',-
(c*xsol+0.5*xsol'*Q*xsol)-100);
```

Input/output:

```
Optimization terminated.
        1250
           0

The value of the objective function is 20837.500000
```

Programming 18:

Write a program in MATLAB to solve the following problem of Inventory.

The demand for an item in a company is 18000 units per year. The company can produce the item at a rate of 3000 per month. The cost of one set-up is Rs. 500 and the holding cost of one unit per month is Rs. 0.15. The shortage cost of one unit is Rs. 20 per month. Determine the optimum manufacturing quantity. Also determine the manufacturing time and the time between setup.

Code:

```
k=input('Enter the production rate: ');
D=input('Enter the demand: ');
c1=input('Enter the holding cost: ');
c2=input('Enter the shortage cost: ');
c3=input('Enter the ordering cost: ');
Q=sqrt(2*c3*(c1+c2)*k*D/(c1*c2*(k-D)));
fprintf('The optimum manufacturing quantity is %0.2f\n',Q);
fprintf('The manufacturing time is %0.2f month\n',Q/k);
fprintf('The time between set ups is %0.2f months\n',Q/D);
```

Input/output:

```
Enter the production rate: 3000
Enter the demand: 1500
Enter the holding cost: 0.15
Enter the shortage cost: 20
Enter the ordering cost: 500
The optimum manufacturing quantity is 4488.88
The manufacturing time is 1.50 month
The time between set ups is 2.99 months
```

Programming 19: ***Write a program in LINGO to solve the following LPP using simplex method.***

$$Min\ z = -3x_1 + 4x_2$$
$$Subject\ to,\ x_1 + x_2 \leq 8$$
$$2x_1 + 5x_2 \leq 22$$
$$x_2 \leq 4$$
$$x_1, x_2 \geq 0$$

Code:

```
min =-3*x1+4*x2;
x1+x2<=8;
 2*x1+5*x2<=22;
 x2<=4;
 x1>=0;
 x2>=0;
```

Input/output:

```
Global optimal solution found.
  Objective value:                              -24.00000
  Infeasibilities:                               0.000000
  Total solver iterations:                              0
  Elapsed runtime seconds:                           0.08

  Model Class:                                         LP

  Total variables:                    2
  Nonlinear variables:                0
  Integer variables:                  0

  Total constraints:                  6
  Nonlinear constraints:              0

  Total nonzeros:                     9
  Nonlinear nonzeros:                 0


                                Variable           Value        Reduced Cost
                                      X1        8.000000            0.000000
                                      X2        0.000000            7.000000

                                     Row    Slack or Surplus      Dual Price
                                       1       -24.00000            1.000000
                                       2        0.000000            3.000000
                                       3        6.000000            0.000000
                                       4        4.000000            0.000000
                                       5        8.000000            0.000000
                                       6        0.000000            0.000000
```

Programming 20: ***Write a script in LINGO to solve the following LPP using Revised Simplex Method.***

$$\text{Max } z = x_1 + x_2$$
$$\text{Subject to, } 3x_1 + 2x_2 \le 6$$
$$x_1 + 4x_2 \le 4$$
$$x_1, x_2 \ge 0$$

Code:

```
max = x1+x2;
3*x1+2*x2<=6;
x1+4*x2<=4;
 x1>=0;
 x2>=0;
```

Input/output:

```
Global optimal solution found.
  Objective value:                              2.200000
  Infeasibilities:                              0.000000
  Total solver iterations:                             2
  Elapsed runtime seconds:                          0.05

  Model Class:                                        LP

  Total variables:                      2
  Nonlinear variables:                  0
  Integer variables:                    0

  Total constraints:                    5
  Nonlinear constraints:                0

  Total nonzeros:                       8
  Nonlinear nonzeros:                   0


                                Variable           Value        Reduced Cost
                                      X1        1.600000            0.000000
                                      X2       0.6000000            0.000000

                                     Row    Slack or Surplus      Dual Price
                                       1        2.200000            1.000000
                                       2        0.000000           0.3000000
                                       3        0.000000           0.1000000
                                       4        1.600000            0.000000
                                       5       0.6000000            0.000000
```

Programming 21: ***Write a program in LINGO to solve the following QPP using Wolfe's modified simplex method***

$$Max\ z = 4x_1 + 6x_2 - 2x_1^2 - 2x_1x_2 - 2x_2^2$$

$$Subject\ to,\ x_1 + 2x_2 \leq 2$$

$$x_1, x_2 \geq 0$$

Code:

```
max=4*x1+6*x2-2*x1*x1-2*x1*x2-2*x2*x2;
 x1+2*x2<=2;
 x1>=0;
 x2>=0;
```

Input/output:

```
 Global optimal solution found.
  Objective value:                              4.166667
  Infeasibilities:                              0.1228329E-07
  Total solver iterations:                             7
  Elapsed runtime seconds:                          0.09
  Model is convex quadratic

  Model Class:                                        QP

  Total variables:                      2
  Nonlinear variables:                  2
  Integer variables:                    0

  Total constraints:                    4
  Nonlinear constraints:                1

  Total nonzeros:                       6
  Nonlinear nonzeros:                   3


                                Variable           Value        Reduced Cost
                                      X1       0.3333084        0.7471752E-04
                                      X2       0.8333458        0.2201430E-07

                                     Row    Slack or Surplus      Dual Price
                                       1        4.166667            1.000000
                                       2      -0.1228329E-07        1.000000
                                       3       0.3333084            0.000000
                                       4       0.8333458            0.000000
```

Programming 22: ***Write a script in LINGO to solve the following LPP using Revised Simplex Method.***

$$\text{Max } z = 7x_1 + 9x_2$$
$$\text{Subject to, } -x_1 + 3x_2 \leq 6$$
$$7x_1 + x_2 \leq 35$$
$$x_1, x_2 \geq 0 \text{ and are integers}$$

Code:

```
max=7*x1+9*x2;
 -x1+3*x2<=6;
 7*x1+x2<=35;
x1>=0;
x2>=0;
@gin(x1);
 @gin(x2);
```

Input/output:

```
Global optimal solution found.
Objective value:                              55.00000
Objective bound:                              55.00000
Infeasibilities:                              0.000000
Extended solver steps:                               0
Total solver iterations:                             0
Elapsed runtime seconds:                          0.07

Model Class:                                      PILP

Total variables:                      2
Nonlinear variables:                  0
Integer variables:                    2

Total constraints:                    5
Nonlinear constraints:                0

Total nonzeros:                       8
Nonlinear nonzeros:                   0


                              Variable           Value        Reduced Cost
                                    X1        4.000000           -7.000000
                                    X2        3.000000           -9.000000

                                   Row    Slack or Surplus      Dual Price
                                     1        55.00000            1.000000
                                     2        1.000000            0.000000
                                     3        4.000000            0.000000
                                     4        4.000000            0.000000
                                     5        3.000000            0.000000
```

Programming 23: ***Write a program in LINGO to solve the following problem using Dynamic programming technique***

$Max\ Z = y_1 y_2 y_3$

Subject to, $y_1 + y_2 + y_3 = 5$

$y_1, y_2, y_3 \geq 0$

Code:

```
max=y1*y2*y3;
 y1+y2+y3=5;
 y1>=0;
 y2>=0;
 y3>=0;
```

Input/output:

```
Local optimal solution found.
Objective value:                              4.629630
Infeasibilities:                              0.000000
Extended solver steps:                               5
Best multistart solution found at step:              1
Total solver iterations:                            59
Elapsed runtime seconds:                          0.18

Model Class:                                       NLP

Total variables:                      3
Nonlinear variables:                  3
Integer variables:                    0

Total constraints:                    5
Nonlinear constraints:                1

Total nonzeros:                       9
Nonlinear nonzeros:                   3


                    Variable           Value        Reduced Cost
                          Y1        1.666667        0.5273961E-08
                          Y2        1.666667            0.000000
                          Y3        1.666667        0.3079834E-08

                         Row    Slack or Surplus      Dual Price
                           1        4.629630            1.000000
                           2        0.000000            2.777778
                           3        1.666667            0.000000
                           4        1.666667            0.000000
                           5        1.666667            0.000000
```

Programming 24: ***Write a program in LINGO to solve the following Geometric Programming Problem***

$$Minimize\ f(x) = 7x_1x_2^{-1} + 3x_2x_3^{-2} + 5x_1^{-3}x_2x_3 + x_1x_2x_3$$

Code:

```
max =z;
 z=(7/c1)^c1*(3/c2)^c2*(5/c3)^c3*(1/c4)^c4;
c1+c2+c3+c4=1;
 1*c1+0*c2-3*c3+1*c4=0;
-1*c1+1*c2+1*c3+1*c4=0;
 0*c1-2*c2+1*c3+1*c4=0;
7*x1/x2=z*c1;
 3*x2/x3^2=z*c2;
 5*x2*x3/x1^3=z*c3;
x1*x2*x3=z*c4;
```

Input/output:

```
Local optimal solution found.
  Objective value:                              15.23023
  Infeasibilities:                              0.000000
  Total solver iterations:                            21
  Elapsed runtime seconds:                          0.05

  Model Class:                                       NLP

  Total variables:                    8
  Nonlinear variables:                8
  Integer variables:                  0

  Total constraints:                 10
  Nonlinear constraints:              5

  Total nonzeros:                    38
  Nonlinear nonzeros:                22


                                Variable           Value        Reduced Cost
                                       Z        15.23023            0.000000
                                      C1       0.5000000            0.000000
                                      C2       0.1666667            0.000000
                                      C3       0.2083333            0.000000
                                      C4       0.1250000            0.000000
                                      X1        1.316074            0.000000
                                      X2        1.209768            0.000000
                                      X3        1.195733            0.000000

                                     Row    Slack or Surplus      Dual Price
                                       1        15.23023            1.000000
                                       2        0.000000            0.000000
                                       3        0.000000           -15.23023
                                       4        0.000000            0.000000
                                       5        0.000000            0.000000
                                       6        0.000000            0.000000
```

```
 7        0.000000          -1.000000
 8        0.000000          -1.000000
 9        0.000000          -1.000000
10        0.000000          -1.000000
```

Programming 25:

Write a program in LINGO to solve the following problem of Inventory.

An engineering factory consumes 5000 units of a component per year. The ordering, receiving and handling cost are Rs.300 per order while trucking cost is Rs.1200 per order, internet cost Rs. 0.06per unit per year, Deterioration and obsolence cost Rs 0.004 per year and storage cost Rs. 1000 per year for 5000 units. Calculate the economic order quantity and minimum average cost.

Code:

```
!Demand = D;
D=5000;
 !Ordering cost per order = C3;
C3=1200+300;
 !Inventory holding Cost = C1;
C1=0.06+0.004+(1000/5000);
 !Economic Order Quantity = Q;
M=(2*C3*D)/C1;
 Q=@SQRT(M);
!The minimum average cost ;
 C=@SQRT(2*C1*C3*D);
```

Input/output:

```
 Feasible solution found.
 Total solver iterations:                              0
 Elapsed runtime seconds:                           0.05

 Model Class:                                      . . .

 Total variables:                  0
 Nonlinear variables:              0
 Integer variables:                0

 Total constraints:                0
 Nonlinear constraints:            0

 Total nonzeros:                   0
 Nonlinear nonzeros:               0



                                Variable           Value
                                       D        5000.000
                                      C3        1500.000
                                      C1       0.2640000
                                       M    0.5681818E+08
                                       Q        7537.784
                                       C        1989.975

                                     Row    Slack or Surplus
                                       1        0.000000
                                       2        0.000000
                                       3        0.000000
                                       4        0.000000
```

```
5          0.000000
6          0.000000
```

Programming 26: ***Write a program in LINGO to solve the following LPP using simplex method***

$Max\ z = 2x_1 + 3x_2 - x_3$

$subject\ to, 2x_1 + 5x_2 - x_3 \leq 5$

$x_1 + x_2 + 2x_3 = 6$

$2x_1 - x_2 + 3x_3 = 7$

$x_1, x_2, x_3 \geq 0$

Code:

```
max=2*x1+3*x2-x3;
2*x1+5*x2-x3<=5;
 x1+x2+2*x3=6;
2*x1-x2+3*x3=7;
 x1>=0;
x2>=0;
x3>=0;
```

Input/output:

```
Global optimal solution found.
Objective value:                              3.000000
Infeasibilities:                              0.000000
Total solver iterations:                             3
Elapsed runtime seconds:                          0.05

Model Class:                                        LP

Total variables:                      3
Nonlinear variables:                  0
Integer variables:                    0

Total constraints:                    7
Nonlinear constraints:                0

Total nonzeros:                      15
Nonlinear nonzeros:                   0


                              Variable           Value        Reduced Cost
                                    X1        1.000000            0.000000
                                    X2        1.000000            0.000000
                                    X3        2.000000            0.000000

                                   Row    Slack or Surplus      Dual Price
                                     1        3.000000            1.000000
                                     2        0.000000           0.8888889
                                     3        0.000000          -0.8888889
                                     4        0.000000           0.5555556
                                     5        1.000000            0.000000
                                     6        1.000000            0.000000
                                     7        2.000000            0.000000
```

Programming 27: ***Write a program in LINGO to solve the following LPP using Revised simplex method***

$$Min\ z = x_1 + x_2$$
$$subject\ to,\ x_1 + 2x_2 \geq 7$$
$$4x_1 + x_2 \geq 6$$
$$x_1, x_2 \geq 0$$

Code:

```
min=x1+x2;
 x1+2*x2>=7;
 4*x1+x2>=6;
 x1>=0;
 x2>=0;
```

Input/output:

```
Global optimal solution found.
Objective value:                              3.857143
Infeasibilities:                              0.000000
Total solver iterations:                             2
Elapsed runtime seconds:                          0.05

Model Class:                                        LP

Total variables:                      2
Nonlinear variables:                  0
Integer variables:                    0

Total constraints:                    5
Nonlinear constraints:                0

Total nonzeros:                       8
Nonlinear nonzeros:                   0


                              Variable           Value        Reduced Cost
                                    X1       0.7142857            0.000000
                                    X2        3.142857            0.000000

                                   Row    Slack or Surplus      Dual Price
                                     1        3.857143           -1.000000
                                     2        0.000000          -0.4285714
                                     3        0.000000          -0.1428571
                                     4       0.7142857            0.000000
                                     5        3.142857            0.000000
```

Programming 28: ***Write a program in LINGO to solve the following QPP using Wolfe's modified simplex method***

Max $z = 2x_1 + 3x_2 - x_1^2$

Subject to, $x_1 + 2x_2 \leq 4$

$x_1, x_2 \geq 0$

Code:

```
max=2*x1+3*x2-x1^2;
 x1+2*x2<=4;
 x1>=0;
x2>=0;
```

Input/output:

```
Global optimal solution found.
Objective value:                              6.062500
Infeasibilities:                              0.000000
Total solver iterations:                             6
Elapsed runtime seconds:                          0.05
Model is convex quadratic

Model Class:                                        QP

Total variables:                    2
Nonlinear variables:                1
Integer variables:                  0

Total constraints:                  4
Nonlinear constraints:              1

Total nonzeros:                     6
Nonlinear nonzeros:                 1


                              Variable           Value        Reduced Cost
                                    X1       0.2500000        0.1324148E-07
                                    X2        1.875000       -0.1108225E-08

                                   Row    Slack or Surplus      Dual Price
                                     1        6.062500            1.000000
                                     2        0.000000            1.500000
                                     3       0.2500000            0.000000
                                     4        1.875000            0.000000
```

Programming 29: ***Write a script in LINGO to solve the following LPP using Revised Simplex Method.***

$$Max\ z = x_1 + x_2$$
$$Subject\ to,\ 3x_1 + 2x_2 \leq 5$$
$$x_2 \leq 2$$
$$x_1, x_2 \geq 0\ and\ are\ integers$$

Code:

```
max=x1+x2;
 3*x1+2*x2<=5;
 x2<=2;
 x1>=0;
x2>=0;
 @gin(x1);
 @gin(x2);
```

Input/output:

```
  Global optimal solution found.
  Objective value:                              2.000000
  Objective bound:                              2.000000
  Infeasibilities:                              0.000000
  Extended solver steps:                               0
  Total solver iterations:                             0
  Elapsed runtime seconds:                          0.06

  Model Class:                                      PILP

  Total variables:                      2
  Nonlinear variables:                  0
  Integer variables:                    2

  Total constraints:                    5
  Nonlinear constraints:                0

  Total nonzeros:                       7
  Nonlinear nonzeros:                   0



                                Variable           Value        Reduced Cost
                                      X1        1.000000           -1.000000
                                      X2        1.000000           -1.000000

                                     Row    Slack or Surplus      Dual Price
                                       1        2.000000            1.000000
                                       2        0.000000            0.000000
                                       3        1.000000            0.000000
                                       4        1.000000            0.000000
                                       5        1.000000            0.000000
```

Programming 30: ***Write a program in LINGO to solve the following problem using Dynamic programming technique***

$$Min\ Z = y_1^2 + y_2^2 + y_3^2$$

$$Subject\ to,\ y_1 + y_2 + y_3 \geq 15$$

$$y_1, y_2, y_3 \geq 0$$

Code:

```
min=y1^2+y2^2+y3^2;
 y1+y2+y3>=15;
 y1>=0;
 y2>=0;
 y3>=0;
```

Input/output:

```
Global optimal solution found.
Objective value:                              75.00000
Infeasibilities:                              0.000000
Total solver iterations:                             5
Elapsed runtime seconds:                          0.05
Model is convex quadratic

Model Class:                                        QP

Total variables:                      3
Nonlinear variables:                  3
Integer variables:                    0

Total constraints:                    5
Nonlinear constraints:                1

Total nonzeros:                       9
Nonlinear nonzeros:                   3


                            Variable           Value        Reduced Cost
                                  Y1        5.000000            0.000000
                                  Y2        5.000000            0.000000
                                  Y3        5.000000            0.000000

                                 Row    Slack or Surplus      Dual Price
                                   1        75.00000           -1.000000
                                   2        0.000000           -10.00000
                                   3        5.000000            0.000000
                                   4        5.000000            0.000000
                                   5        5.000000            0.000000
```

Programming 31:

Write a program in LINGO to solve the following problems of Inventory.

A constructer has to supply 10,000 bearing per day to an auto-mobile manufacturer. He find that when he start a production run, he can produce 25,000 bearing per day .The cost of holding a bearing in stock for one year is Rs 2 and set up cost for producing run is Rs 180.How frequently should the production ?

Code:

```
!Demand per day = D ;
 D=10000;
 !Production rate = K;
K=25000;
!Ordering Cost = C3;
C3=180;
 !Inventory holding cost per day = C1;
 C1=2/365;
 !Economic Order Quantity = Q;
 Q=@SQRT(2*C3*D*K/(C1*(K-D)));
 !Frequency Production;
T=Q/D;
```

Input/output:

```
Feasible solution found.
Total solver iterations:                        0
Elapsed runtime seconds:                     0.05

Model Class:                                . . .

Total variables:                  0
Nonlinear variables:              0
Integer variables:                0

Total constraints:                0
Nonlinear constraints:            0

Total nonzeros:                   0
Nonlinear nonzeros:               0


                                Variable           Value
                                       D        10000.00
                                       K        25000.00
                                      C3        180.0000
                                      C1   0.5479452E-02
                                       Q        33090.78
                                       T        3.309078

                                     Row    Slack or Surplus
                                       1           0.000000
                                       2           0.000000
                                       3           0.000000
                                       4           0.000000
                                       5           0.000000
                                       6           0.000000
```

Programming 32: ***Write a program in LINGO to solve the following LPP using simplex method***

$Max\ z = 3x_1 + 4x_2$

$subject\ to,\ x_1 + x_2 \leq 10$

$2x_1 + 3x_2 \leq 18$

$x_1 \leq 8$

$x_2 \leq 6$

$x_1, x_2 \geq 0$

Code:

```
max=3*x1+4*x2;
x1+x2<=10;
 2*x1+3*x2<=18;
 x1<=8;
 x2<=6;
 x1>=0;
 x2>=0;
```

Input/output:

```
Global optimal solution found.
  Objective value:                              26.66667
  Infeasibilities:                              0.000000
  Total solver iterations:                             1
  Elapsed runtime seconds:                          0.04

  Model Class:                                        LP

  Total variables:                      2
  Nonlinear variables:                  0
  Integer variables:                    0

  Total constraints:                    7
  Nonlinear constraints:                0

  Total nonzeros:                      10
  Nonlinear nonzeros:                   0


                                Variable           Value        Reduced Cost
                                      X1        8.000000            0.000000
                                      X2       0.6666667            0.000000

                                     Row    Slack or Surplus      Dual Price
                                       1        26.66667            1.000000
                                       2        1.333333            0.000000
                                       3        0.000000            1.333333
                                       4        0.000000           0.3333333
                                       5        5.333333            0.000000
                                       6        8.000000            0.000000
                                       7       0.6666667            0.000000
```

Programming 33:

Write a program in LINGO to solve the following problem of Inventory.

The demand for an item is deterministic and constant over time and is equal to 600 units per year. The unit cost of the item is Rs. 50.00 while the cost of placing an order is Rs. 100.00. The inventory carrying cost is 20% of the item and the shortage cost per month is Rs. 1.Find the optimal ordering quantity. If shortages are not allowed, what would be the loss of the company ?

Code:

```
! Demand per year = D ;
 D=600;
 ! Ordering cost per year = C3;
C3=100;
 ! Inventory holding cost per unit per year = C1;
 C1=20*50/100;
! Shortage cost per year = C2;
 C2=1*12;
 ! Economic order quantity=Q1;
 Q1=@SQRT((2*C3*(C1+C2)*D)/(C1*C2));
!The minimum average cost ;
C=@SQRT((2*C1*C2*C3*D)/(C1+C2));
 ! The minimum average cost when shortages are not allowed;
 CS=@SQRT(2*C1*C3*D);
 !If the shortages are not allowed the loss of the company =
loss;
LOSS=CS-C;
```

Input/output:

```
Feasible solution found.
Total solver iterations:                              0
Elapsed runtime seconds:                           0.06

Model Class:                                      . . .

Total variables:                  0
Nonlinear variables:              0
Integer variables:                0

Total constraints:                0
Nonlinear constraints:            0

Total nonzeros:                   0
Nonlinear nonzeros:               0


                                         Variable           Value
                                                D        600.0000
                                               C3        100.0000
                                               C1        10.00000
                                               C2        12.00000
                                               Q1        148.3240
                                                C        809.0398
```

```
            CS        1095.445
          LOSS        286.4053

      Row  Slack or Surplus
        1         0.000000
        2         0.000000
        3         0.000000
        4         0.000000
        5         0.000000
        6         0.000000
        7         0.000000
        8         0.000000
```

Programming 34:

Write a program in LINGO to solve the following problem of Inventory.

The demand for an item in a company is 18000 units per year. The company can produce the item at a rate of 3000 per month. The cost of one set-up is Rs. 500 and the holding cost of one unit per month is Rs. 0.15. The shortage cost of one unit is Rs. 20 per month. Determine the optimum manufacturing quantity. Also determine the manufacturing time and the time between setup.

Code:

```
! Demand per month = D;
 D=1500;
 !Production rate per month = K;
K=3000;
 !Set up cost =C3;
 C3=500;
!INVENTORY COST PER UNIT PER DAY=C1;
 C1=0.15;
 !SORTAGE COST =C2;
C2=20;
!Economic order quantity=Q;
 Q=@SQRT(2*C3*(C1+C2)*D*K/(C1*C2*(K-D)));
 !Manufacturing time ;
 MT=Q/K;
 !Time between set ups ;
T=Q/D;
```

Input/output :

```
Feasible solution found.
  Total solver iterations:                              0
  Elapsed runtime seconds:                           0.03

  Model Class:                                      . . .

  Total variables:                      0
  Nonlinear variables:                  0
  Integer variables:                    0

  Total constraints:                    0
  Nonlinear constraints:                0

  Total nonzeros:                       0
  Nonlinear nonzeros:                   0


                                Variable           Value
                                       D        1500.000
                                       K        3000.000
                                      C3        500.0000
                                      C1       0.1500000
```

```
                    C2        20.00000
                     Q        4488.875
                    MT        1.496292
                     T        2.992583

                   Row    Slack or Surplus
                     1        0.000000
                     2        0.000000
                     3        0.000000
                     4        0.000000
                     5        0.000000
                     6        0.000000
                     7        0.000000
                     8        0.000000
```

Programming 35: ***Write a program in MATLAB to solve the following QPP using Wolfe's modified simplex method***

Max $z = 18x_1 + 3x_2 - 0.001x_1^2 - 0.005x_2^2 - 100$

Subject to, $2x_1 + 3x_2 \leq 2500$

$x_1 + 2x_2 \leq 1500$

$x_1, x_2 \geq 0$

Code:

```
max=18*x1+3*x2-0.001*x1^2-0.005*x2^2-100;
 2*x1+3*x2<=2500;
x1+2*x2<=1500;
 x1>=0;
 x2>=0;
```

Input/output:

```
Global optimal solution found.
Objective value:                              20837.50
Infeasibilities:                            0.3936128E-05
Total solver iterations:                             9
Elapsed runtime seconds:                          0.09
Model is convex quadratic

Model Class:                                        QP

Total variables:                    2
Nonlinear variables:                2
Integer variables:                  0

Total constraints:                  5
Nonlinear constraints:              1

Total nonzeros:                     8
Nonlinear nonzeros:                 2


                              Variable           Value        Reduced Cost
                                    X1        1250.000       -0.1191609E-05
                                    X2       0.3332747E-06        20.25000

                                   Row    Slack or Surplus      Dual Price
                                     1        20837.50            1.000000
                                     2      -0.3936128E-05        7.749999
                                     3        250.0000        0.2594180E-07
                                     4        1250.000            0.000000
                                     5       0.3332747E-06        0.000000
```