Question 1:

```
clc;
clear;

%Part a)
nVar=6;
% Build reference matrix of indices (that is we have 2 indi-
ces (i,j) and
% 5*6 variables x_ij.
id= zeros(nVar*(nVar-1),2);
row=1;
for i=1 : (nVar-1)
    for j=1 :nVar
        id(row,1)=i;
        id(row,2)=10*j;
        row=row+1;
    end
end

% Now, we are constructing the first constraint in the
mathematical model
% That is the summation on j of x_ij equal to one. spalloc
function assigns
% a space to the equality matrix (to hold five constraints
with 30
% variables inside)
% This loop presents the matrix of coefficients of the first
constraint;
% visually we are trying to build sth like this:
%   1 2 3 4 5 6 7 8 9 10 11 12 ... 30
```

```
% 1 1 1 1 1 1 1 0 0 0  0 0  0  ... 0
% 2 0 0 0 0 0 0 1 1 1  1 1  1  ... 0
% 3 ...
% 4 ...
% 5 ...

Aeq = [spalloc(nVar-1,length(id),nVar*(nVar-1))]; % allo-
cate a sparse matrix
beq= ones(nVar-1,1);
for i = 1:nVar-1
   whichIdxs = (id == i); % this line calls the i th job.
   whichIdxs = sparse(sum(whichIdxs,2)); %
   Aeq(i,:) = whichIdxs; % include in the constraint matrix
end

% The following loop presents the inequality constraint in
the assignment
% mathematical formulation.

A = [spalloc(nVar,length(id),nVar*(nVar-1))]; % allocate a
sparse matrix
b=ones(nVar,1);
for i = 1:nVar
   whichIdxs = (id == 10*i); % find the trips that include
stop 10*i
   whichIdxs = sparse(sum(whichIdxs,2));
   A(i,:) = whichIdxs; % include in the constraint matrix
end
% All variables are in fact binary however, we solve the
problem for the
% relaxation case. Below, you find the upper and lower
bound [0,1]
```

```
lb=zeros(30,1);
ub=ones(30,1);

% Here is the coefficients of variables in the objective
function
Cost=[50,55,42,57,48,52,
66,70,64,68,75,63,81,78,72,80,85,78, 40,42,38,45,46,42,
62,55,58,60,56,65];

% Now, we solve the LP model using linprog function.
[xa,fvala]=linprog(Cost,A,b,Aeq,beq,lb,ub);


% Part (b)
% In this case we should add the following equation to the
original model:
% x11+x13=1
Add=zeros(1,30);
% by looking at id matrices we can identify the variable
references which
% is 1 and 3 therefore,
Add(1,1)=1;
Add(1,3)=1;
bAeq=[Aeq;Add]; % adds an equality row to the matrix that
was defined by Aeq
bbeq=[beq;1]; % add the corresponding RHS
[xb,fvalb]=linprog(Cost,A,b,bAeq,bbeq,lb,ub);


%  Part (c)
% in this section we have to add two variables to the prob-
lem
```

```
% the valid inequalities are:
% x_41+x_42+x_43+x_51+x_52+x_53>=2*y1
% x_44+x_45+x_46+x_54+x_55+x_56>=2*y2
% y1+y2 =1;
% in order to solve it first we need to add two variables to
our matrices

cCost=[Cost 0 0];
% we add two extra columns to the matrix of coefficients
and append them
% the previous matrix of coefficients
AddColeq=zeros(5,2);
cAeq=[Aeq AddColeq];

% Two columns are added to the matrix of inequalities
same as above.
AddColIneq=zeros(6,2);
cA=[A AddColIneq];

% add first constraint
Add=zeros(1,32);
Add(1,19)=-1;Add(1,20)=-1;Add(1,21)=-1;
Add(1,25)=-1;Add(1,26)=-1;Add(1,27)=-1;
% the following line is the coefficient of y_1.
Add(1,31)=2;

%Matrix of inequalities of part c)
cA=[cA;Add];  % add first constraint to the matrix
cb=[b;0]; % add the corresponding RHS

Add=zeros(1,32);
Add(1,22)=-1;Add(1,23)=-1;Add(1,24)=-1;
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Add(1,28)=-1;Add(1,29)=-1;Add(1,30)=-1;
% the following line is the coefficient of y_2.
Add(1,32)=2;

cA=[cA;Add];  %add second constraint to the matrix
cb=[cb;0]; % add the corresponding RHS

% add last constraint that is y_1+y_2=1
Add=zeros(1,32);
Add(1,31)=1;Add(1,32)=1;
cAeq=[cAeq;Add];
cbeq=[beq;1];

%solve the problem
[xc,fvalc]=linprog(cCost,cA,cb,cAeq,cbeq,lb,ub);
```

Question 2:

```
clc;
clear;

% (a)
%MATLAB solves minimization problem that is why the
coefficients in the
%objective function are negative
f = [-12.95, -7.08, -7.08, -5.9, -6, -4.72, -1.18, -23.6];
```

```
A = [11,6, 6, 5, 5, 4, 1, 20];
b = [19];
% for relaxation problem x changes between zero and one
lb=zeros(8,1);
ub=ones(8,1);
[xa,fvala]=linprog(f,A,b,[],[],lb,ub);
% (b)
%the coefficient of the variable 8 equals to 20, that is, in
case x=1, the constraint is already
% violated. Therefore, this variable could be eliminated
from the model by
% fixing x=0.


% (c)
%In the previous part, we have already eliminated x8 by
fixing its value to
%zero. Then for the remaining we have to write all the
possible combinations and
% add them to the model.
Con0 =[0,0,0,0,0,0,0,1];
Con1 =[1,1,1,0,0,0,0,1];
Con2 =[1,1,0,1,0,0,0,1];
Con3 =[1,1,0,0,1,0,0,1];
Con4 =[1,1,0,0,0,1,0,1];
Con5 =[1,0,1,1,0,0,0,1];
Con6 =[1,0,1,0,1,0,0,1];
Con7 =[1,0,1,0,0,1,0,1];
Con8 =[1,0,0,1,1,0,0,1];
Con9=[1,0,0,1,0,1,0,1];
Con10=[1,0,0,0,1,1,0,1];
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```
Con11=[0,1,1,1,1,0,0,1];
Con12=[0,1,1,1,0,1,0,1];
Con13=[0,1,1,0,1,1,0,1];
Con14=[0,1,0,1,1,1,0,1];
Con15=[0,0,1,1,1,1,0,1];

% We append the above mentioned constraints into the
matrix of the
% coefficients as well as the vector b.
Ac=[A;Con0;Con1;Con2;Con3;Con4;Con5;Con6;Con7;Co
n8;Con9;Con10;Con11;
    Con12;Con13;Con14;Con15];
bc=[b;0;2;2;2;2;2;2;2;2;2;2;3;3;3;3;3];
[xc,fvalc]=linprog(f,Ac,bc,[],[],lb,ub);

% (d)

Con16=[2,1,1,1,1,1,0,1];
Ad=[Ac;Con16];
bd=[bc;3];
[xd,fvald]=linprog(f,Ad,bd,[],[],lb,ub);

% (e)
%sort the coefficient of the constraint in descending order
Mat=[f;A];
[Y,I]=sort(Mat(2,:),'descend');
B=Mat(:,I);

Bound=19;
VAR=zeros(1,8);
Cap=0;
Obj=0;
```

```matlab
for i=1:8
    if(Cap+B(2,i)<=Bound)
        Cap=Cap+B(2,i);
        VAR(1,i)=1;
        Obj=Obj+B(1,i);
    end
end


% (f) we sort the values based on their marginal profit
%MProfit=Marginal Profit
MProfit=zeros(1,8);
for i=1:8
    MProfit(1,i)=-f(1,i)/A(1,i);
end

MATF=[MProfit;f;A];
BF = sortrows(MATF,1);

Bound=19;
VARF=zeros(1,8);
CapF=0;
ObjF=0;
for i=2:8
    if(CapF<=Bound)
        CapF=CapF+BF(3,i);
        VARF(1,i)=1;
        ObjF=ObjF+BF(1,i);
    end
end
```