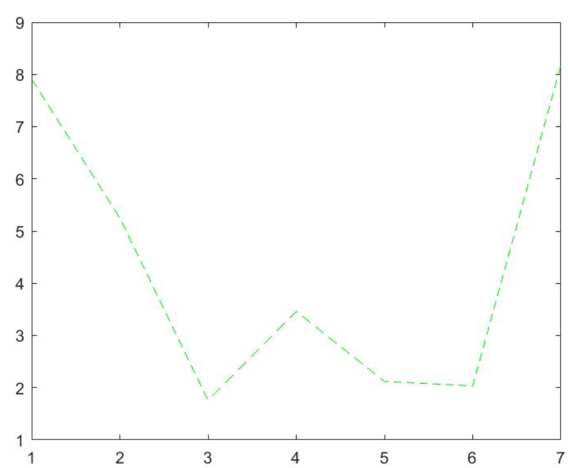
2(a) source code and graph

```
%load data according to the question
 d = load( 'detroit.mat' );
 %process data
 s = d.data(:, 9:10);
 %definition
 v = [1;1;1;1;1;1;1;1;1;1;1;1;1];
 e = [] ;
 %variables and factors
 HOM = d.data(:,10);
 LIC = d.data(:,4);
 FTP = d.data(:,1);
 WE = d.data(:,9);
 matrix = [v, FTP, WE];
 %procedures
 i = 2
 while(i < 9)
     store = d.data(:,i);
     new = [matrix, store];
     %formula
     b = (((new')*new)^(-1))*(new')*HOM;
     y = new * b ;
     sub = y - HOM;
     sub2 = sub.^2;
     e1 = sum(sub2);
     l_e = e1/(2*13);
     e = [e; l_e];
     i = i + 1 ;
 end
result = e
plot(result,'--','color',[0 0.9 0]);
```



2(b) Since I can’t figure out how to use Matlab to process lenses and CA data, I use Python to work on this question. To process the data, I use Panda Package.

i. I replaced all unknow first features. Then I calculate median of possible values of the missing features that are not numbers. I also replace the attribute by the mode of all attributes. Finally, I use label conditioned mean for real-valued with plus label. The formula is

$$\frac{sum\ of\ plus\ label\ data\ set's\ all\ feature}{no.\ of\ plus\ label\ data\ set}$$

As for minus data set, the formula is $\frac{sum\ of\ minus\ label\ data\ set's\ all\ feature}{no.\ of\ minus\ label\ data\ set}$

The detailed procedures are below and in process.py.

```
#Use Panda to process data
from sys import argv
import pandas as pd
import numpy as np
#command run
script, a, b = argv
#function below
def process(data):
    data = data.replace('?', np.NaN)
    r = [0,3,4,5,6]
  #missing features
    column = [1,2,7,10,13,14]
    for i in r:
    #replace by mode
            data[i] = data[i].fillna(data[i].mode()[0])
    r = [1,13]
  #plus, minus label
    lab = ['+', '-']
    for m in r:
            data[m] = data[m].apply(float)
            for n in lab:
      #get real-value missing ones
                    data.loc[ (data[m].isnull()) & ( data[15]==n ), m ] =
data[m][data[15] == n].mean()
    for c in column:
            data[c] = (data[c] - data[c].mean())/data[c].std()
    return data

#Use panda to process TrD which stands for training Data and TeD which stands for testing data
TrD = pd.read_csv(a, header=None)
#process the data
TrD = process(TrD)
TrD.to_csv('crx.training.processed', header=False, index=False)
```

```
#Same Usage as above
TeD= pd.read_csv(b, header=None)
TeD = process(TeD)
TeD.to_csv('crx.testing.processed', header=False, index=False)
```

ii. KNN theory and its knowledge are cited from
*https://en.wikipedia.org/wiki/K-nearest_neighbors_algorithm
*https://www.analyticsvidhya.com/blog/2018/03/introduction-k-neighbours-algorithm-clustering/
In this question, I am required to write a k-NN algorithm with L2 distance which is $D_{L2}(a,b)=\sqrt{\sum_i (a_i - b_i)^2}$
To run the program under command lines, I still use sys import argv in Python. The command line in this case should have 3 parameters. There are 2 scripts needed to run with the Python to make the command work. The code is below:

```
import math
from sys import argv
import pandas as pd
#command run, parameters
script, KNN, Tr, Te = argv
#Use panda to read
TrD = pd.read_csv(Tr, header=None)
TeD = pd.read_csv(Te, header=None)
LAB = []
R1, C1 = TrD.shape
R2, C2 = TeD.shape
nei = []

#find real label to its testing data
def label(list1, TrD):
   for i in range(len(list1)):
      label = TrD.iloc[list1[i]][ C1-1 ]
      LAB.append(label)
      #need the label with most times
   return max(set(LAB), key=LAB.count)

#distance is calculated below
def dist(m,n):
   res = 0
```

```
    list = []
    for i in range(R1):
        for j in range(C1 - 1 ):
            if(isinstance(m.iloc[i][j], str ) == True):
                if(m.iloc[i][j] != n[j]):
                    res = res + 1
                else:
                    res = res
            else:
                #DL2(m,n) = sqrt(res(m , n)^2))
                diff = math.pow((m.iloc[i][j] - n[j]), 2)
                res = res + diff
        list.append(math.sqrt(res))
        res = 0
    return list

TeD[C2] = TeD[C2-1]
a = 0
#run through the data
for index,row in TeD.iterrows():
    dis = dist(TrD,row)
    ordered = sorted(range(len(dis)), key=lambda k: dis[k])
    for i in range(int(KNN)):
        nei.append(ordered[i])
    res = label(nei, TrD)
    TeD.loc[a, C2] = res
    a = a + 1

#use panda to output
TeD.to_csv(Te, header=False, index=False)
```

iii. The accuracy result is below:

k	Lenses Acc	Crx Acc
1	7/7	131/132
3	7/7	131/132

iv. Citation:

Theory and knowledge of KNN are referenced from
*https://en.wikipedia.org/wiki/K-nearest_neighbors_algorithm
*https://www.analyticsvidhya.com/blog/2018/03/introduction-k-neighbours-algorithm-clustering/