HW2

February 14, 2017

1 Homework 2

1.1 Problem 1

1.1.1 Part (a)

In [1]:
```
import numpy as np
from math import *

#Inputing the atomic number.
Z=int(input("Enter atomic number: "))
#Creating a list that contains zeros.
BindingEnergyPerNucleonList=np.zeros(3*Z-Z+1)
#Counter to run though the BindingEnergyPerNucleonList list.
l=0
#First four liquid drop model constants.
a1 = 15.67
a2 = 17.23
a3 = 0.75
a4 = 93.2
#Ranging mass number
for A in range(Z, 3*Z+1):
    #Fifth liquid drop model constant.
    if A%2!=0:
        a5=0.
    elif A%2==0 and Z%2==0:
        a5=12.
    elif A%2==0 and Z%2!=0:
        a5=-12.
    #Calculation of binding energy per nucleon for a given mass number A.
    BE=(a1*A)-(a2*A**(2./3.))-(a3*(Z**2.)/(A**(1./3.)))-((a4*(A-2.*Z)**2.)/A)+\
    (a5/(A**(1./2.)))
    BEPN=BE/A
    #Filling up the BindingEnergyPerNucleonList list.
    BindingEnergyPerNucleonList[l]=BEPN
    #Finding the maximum binding energy per nucleon for the given mass number A.
    if BEPN==BindingEnergyPerNucleonList.max():
        MaxMassNumber=A
```

```
            if Z==1:
                MaxMassNumber=2
            l+=1
        MaxBEPN=BindingEnergyPerNucleonList.max()
        print("The binding energy for an atom with atomic number {0} is maximized when its\
        mass number is:{1}".format(Z,MaxMassNumber))
        print("The corresponding binding energy per nucleon is {0} MeV".format(MaxBEPN))
```

```
Enter atomic number: 28
The binding energy for an atom with atomic number 28 is maximized when itsmass number is:58
The corresponding binding energy per nucleon is 8.516131151747729 MeV
```

1.1.2 Part (b)

```
In [9]: import numpy as np
        from math import *

        #Creating a list that contains the atomic numbers of interest.
        AtomicNumberList=np.arange(1,101)
        #Creating a list that contains zeros.
        MaxBindingEnergyPerNucleonList=np.zeros(100)
        #Going through all the atomic numbers of interest.
        for m in range(100):
            #Creating a list that contains zeros.
            BindingEnergyPerNucleonList=np.zeros(3*AtomicNumberList[m]-AtomicNumberList[m]+1)
            #Counter to run though the BindingEnergyPerNucleonList list.
            l=0
            #First four liquid drop model constants.
            a1 = 15.67
            a2 = 17.23
            a3 = 0.75
            a4 = 93.2
            #Ranging mass number
            for A in range(AtomicNumberList[m], 3*AtomicNumberList[m]+1):
                #Fifth liquid drop model constant.
                if A%2!=0:
                    a5=0.
                elif A%2==0 and AtomicNumberList[m]%2==0:
                    a5=12.
                elif A%2==0 and AtomicNumberList[m]%2!=0:
                    a5=-12.
                #Calculation of binding energy per nucleon for a given mass number A.
                BE=(a1*A)-(a2*A**(2./3.))-(a3*(AtomicNumberList[m]**2.)/(A**(1./3.)))-\
                ((a4*(A-2.*AtomicNumberList[m])**2.)/A)+(a5/(A**(1./2.)))
                BEPN=BE/A
                #Filling up the BindingEnergyPerNucleonList list.
                BindingEnergyPerNucleonList[l]=BEPN
```

```
                #Finding the maximum binding energy per nucleon for the given mass number A.
                if BEPN==BindingEnergyPerNucleonList.max():
                    MaxMassNumber=A
                if AtomicNumberList[m]==1:
                    MaxMassNumber=2
                l+=1
            MaxBEPN=BindingEnergyPerNucleonList.max()
            MaxBindingEnergyPerNucleonList[m]=MaxBEPN
            print("The binding energy for an atom with atomic number {0} is maximized when its\
 mass number is: {1}".format(AtomicNumberList[m],MaxMassNumber))
            print("The corresponding binding energy per nucleon is {0} MeV".format(MaxBEPN))
        #Finding the maximum binding energy per nucleon for the list of mass numbers of interest
        MaximumOfMaxBEPN=MaxBindingEnergyPerNucleonList.max()
        print("The maximum binding energy per nucleon is {0} MeV.".format(MaximumOfMaxBEPN))
        print("From the list above we can see that this corresponds to Z=24"\
        .format(MaximumOfMaxBEPN))
```

```
The binding energy for an atom with atomic number 1 is maximized when its mass number is: 2
The corresponding binding energy per nucleon is -2.5457384470693594 MeV
The binding energy for an atom with atomic number 2 is maximized when its mass number is: 4
The corresponding binding energy per nucleon is 5.843309761445089 MeV
The binding energy for an atom with atomic number 3 is maximized when its mass number is: 6
The corresponding binding energy per nucleon is 4.752357643495461 MeV
The binding energy for an atom with atomic number 4 is maximized when its mass number is: 8
The corresponding binding energy per nucleon is 6.835330085889912 MeV
The binding energy for an atom with atomic number 5 is maximized when its mass number is: 10
The corresponding binding energy per nucleon is 6.42277121416258 MeV
The binding energy for an atom with atomic number 6 is maximized when its mass number is: 12
The corresponding binding energy per nucleon is 7.450001408063262 MeV
The binding energy for an atom with atomic number 7 is maximized when its mass number is: 15
The corresponding binding energy per nucleon is 7.2759287595854785 MeV
The binding energy for an atom with atomic number 8 is maximized when its mass number is: 16
The corresponding binding energy per nucleon is 7.829219179670832 MeV
The binding energy for an atom with atomic number 9 is maximized when its mass number is: 19
The corresponding binding energy per nucleon is 7.7565457636093065 MeV
The binding energy for an atom with atomic number 10 is maximized when its mass number is: 20
The corresponding binding energy per nucleon is 8.075065994502456 MeV
The binding energy for an atom with atomic number 11 is maximized when its mass number is: 23
The corresponding binding energy per nucleon is 8.047741643605248 MeV
The binding energy for an atom with atomic number 12 is maximized when its mass number is: 24
The corresponding binding energy per nucleon is 8.238691826796318 MeV
The binding energy for an atom with atomic number 13 is maximized when its mass number is: 27
The corresponding binding energy per nucleon is 8.23400548696845 MeV
The binding energy for an atom with atomic number 14 is maximized when its mass number is: 28
The corresponding binding energy per nucleon is 8.347948969539557 MeV
The binding energy for an atom with atomic number 15 is maximized when its mass number is: 31
The corresponding binding energy per nucleon is 8.355316017924503 MeV
The binding energy for an atom with atomic number 16 is maximized when its mass number is: 32
```

```
The corresponding binding energy per nucleon is 8.419299763471765 MeV
The binding energy for an atom with atomic number 17 is maximized when its mass number is: 35
The corresponding binding energy per nucleon is 8.433300109655088 MeV
The binding energy for an atom with atomic number 18 is maximized when its mass number is: 36
The corresponding binding energy per nucleon is 8.463130252869773 MeV
The binding energy for an atom with atomic number 19 is maximized when its mass number is: 39
The corresponding binding energy per nucleon is 8.480797498293386 MeV
The binding energy for an atom with atomic number 20 is maximized when its mass number is: 41
The corresponding binding energy per nucleon is 8.495784570724105 MeV
The binding energy for an atom with atomic number 21 is maximized when its mass number is: 43
The corresponding binding energy per nucleon is 8.505969250374267 MeV
The binding energy for an atom with atomic number 22 is maximized when its mass number is: 46
The corresponding binding energy per nucleon is 8.521126546356417 MeV
The binding energy for an atom with atomic number 23 is maximized when its mass number is: 47
The corresponding binding energy per nucleon is 8.51427985673783 MeV
The binding energy for an atom with atomic number 24 is maximized when its mass number is: 50
The corresponding binding energy per nucleon is 8.532622751365931 MeV
The binding energy for an atom with atomic number 25 is maximized when its mass number is: 51
The corresponding binding energy per nucleon is 8.509541272617627 MeV
The binding energy for an atom with atomic number 26 is maximized when its mass number is: 54
The corresponding binding energy per nucleon is 8.529918878483894 MeV
The binding energy for an atom with atomic number 27 is maximized when its mass number is: 55
The corresponding binding energy per nucleon is 8.494502009034267 MeV
The binding energy for an atom with atomic number 28 is maximized when its mass number is: 58
The corresponding binding energy per nucleon is 8.516131151747729 MeV
The binding energy for an atom with atomic number 29 is maximized when its mass number is: 59
The corresponding binding energy per nucleon is 8.471198426724659 MeV
The binding energy for an atom with atomic number 30 is maximized when its mass number is: 62
The corresponding binding energy per nucleon is 8.493539040433166 MeV
The binding energy for an atom with atomic number 31 is maximized when its mass number is: 63
The corresponding binding energy per nucleon is 8.441173961358636 MeV
The binding energy for an atom with atomic number 32 is maximized when its mass number is: 66
The corresponding binding energy per nucleon is 8.463850079532241 MeV
The binding energy for an atom with atomic number 33 is maximized when its mass number is: 69
The corresponding binding energy per nucleon is 8.407023623298558 MeV
The binding energy for an atom with atomic number 34 is maximized when its mass number is: 70
The corresponding binding energy per nucleon is 8.428369633665127 MeV
The binding energy for an atom with atomic number 35 is maximized when its mass number is: 73
The corresponding binding energy per nucleon is 8.378546716689646 MeV
The binding energy for an atom with atomic number 36 is maximized when its mass number is: 74
The corresponding binding energy per nucleon is 8.388113269898794 MeV
The binding energy for an atom with atomic number 37 is maximized when its mass number is: 77
The corresponding binding energy per nucleon is 8.344202808885123 MeV
The binding energy for an atom with atomic number 38 is maximized when its mass number is: 78
The corresponding binding energy per nucleon is 8.343883240098318 MeV
The binding energy for an atom with atomic number 39 is maximized when its mass number is: 81
The corresponding binding energy per nucleon is 8.305002733727862 MeV
The binding energy for an atom with atomic number 40 is maximized when its mass number is: 82
```

```
The corresponding binding energy per nucleon is 8.296321819444412 MeV
The binding energy for an atom with atomic number 41 is maximized when its mass number is: 85
The corresponding binding energy per nucleon is 8.261750510640876 MeV
The binding energy for an atom with atomic number 42 is maximized when its mass number is: 86
The corresponding binding energy per nucleon is 8.24594931259649 MeV
The binding energy for an atom with atomic number 43 is maximized when its mass number is: 89
The corresponding binding energy per nucleon is 8.215093312348952 MeV
The binding energy for an atom with atomic number 44 is maximized when its mass number is: 92
The corresponding binding energy per nucleon is 8.19461382681585 MeV
The binding energy for an atom with atomic number 45 is maximized when its mass number is: 93
The corresponding binding energy per nucleon is 8.165557635885968 MeV
The binding energy for an atom with atomic number 46 is maximized when its mass number is: 96
The corresponding binding energy per nucleon is 8.147660087251849 MeV
The binding energy for an atom with atomic number 47 is maximized when its mass number is: 97
The corresponding binding energy per nucleon is 8.113575920303537 MeV
The binding energy for an atom with atomic number 48 is maximized when its mass number is: 100
The corresponding binding energy per nucleon is 8.09792588469997 MeV
The binding energy for an atom with atomic number 49 is maximized when its mass number is: 101
The corresponding binding energy per nucleon is 8.059506427776757 MeV
The binding energy for an atom with atomic number 50 is maximized when its mass number is: 104
The corresponding binding energy per nucleon is 8.045820701666507 MeV
The binding energy for an atom with atomic number 51 is maximized when its mass number is: 105
The corresponding binding energy per nucleon is 8.003648295151866 MeV
The binding energy for an atom with atomic number 52 is maximized when its mass number is: 108
The corresponding binding energy per nucleon is 7.9916857764084135 MeV
The binding energy for an atom with atomic number 53 is maximized when its mass number is: 111
The corresponding binding energy per nucleon is 7.94645235076544 MeV
The binding energy for an atom with atomic number 54 is maximized when its mass number is: 112
The corresponding binding energy per nucleon is 7.935807480620873 MeV
The binding energy for an atom with atomic number 55 is maximized when its mass number is: 115
The corresponding binding energy per nucleon is 7.893842076428151 MeV
The binding energy for an atom with atomic number 56 is maximized when its mass number is: 116
The corresponding binding energy per nucleon is 7.878427690702502 MeV
The binding energy for an atom with atomic number 57 is maximized when its mass number is: 119
The corresponding binding energy per nucleon is 7.839412042376312 MeV
The binding energy for an atom with atomic number 58 is maximized when its mass number is: 120
The corresponding binding energy per nucleon is 7.819751909047517 MeV
The binding energy for an atom with atomic number 59 is maximized when its mass number is: 123
The corresponding binding energy per nucleon is 7.783406816608566 MeV
The binding energy for an atom with atomic number 60 is maximized when its mass number is: 124
The corresponding binding energy per nucleon is 7.759955682578084 MeV
The binding energy for an atom with atomic number 61 is maximized when its mass number is: 127
The corresponding binding energy per nucleon is 7.726035276958766 MeV
The binding energy for an atom with atomic number 62 is maximized when its mass number is: 130
The corresponding binding energy per nucleon is 7.7005459914990935 MeV
The binding energy for an atom with atomic number 63 is maximized when its mass number is: 131
The corresponding binding energy per nucleon is 7.667476698492233 MeV
The binding energy for an atom with atomic number 64 is maximized when its mass number is: 134
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The corresponding binding energy per nucleon is 7.643787578247822 MeV
The binding energy for an atom with atomic number 65 is maximized when its mass number is: 135
The corresponding binding energy per nucleon is 7.6078856509526185 MeV
The binding energy for an atom with atomic number 66 is maximized when its mass number is: 138
The corresponding binding energy per nucleon is 7.58583969107545 MeV
The binding energy for an atom with atomic number 67 is maximized when its mass number is: 139
The corresponding binding energy per nucleon is 7.547395967121129 MeV
The binding energy for an atom with atomic number 68 is maximized when its mass number is: 142
The corresponding binding energy per nucleon is 7.526853043899859 MeV
The binding energy for an atom with atomic number 69 is maximized when its mass number is: 143
The corresponding binding energy per nucleon is 7.486123979926559 MeV
The binding energy for an atom with atomic number 70 is maximized when its mass number is: 146
The corresponding binding energy per nucleon is 7.46695869996326 MeV
The binding energy for an atom with atomic number 71 is maximized when its mass number is: 149
The corresponding binding energy per nucleon is 7.427989147781526 MeV
The binding energy for an atom with atomic number 72 is maximized when its mass number is: 150
The corresponding binding energy per nucleon is 7.406271043404146 MeV
The binding energy for an atom with atomic number 73 is maximized when its mass number is: 153
The corresponding binding energy per nucleon is 7.369331436311893 MeV
The binding energy for an atom with atomic number 74 is maximized when its mass number is: 154
The corresponding binding energy per nucleon is 7.344890236341641 MeV
The binding energy for an atom with atomic number 75 is maximized when its mass number is: 157
The corresponding binding energy per nucleon is 7.309833806640477 MeV
The binding energy for an atom with atomic number 76 is maximized when its mass number is: 158
The corresponding binding energy per nucleon is 7.282904261469813 MeV
The binding energy for an atom with atomic number 77 is maximized when its mass number is: 161
The corresponding binding energy per nucleon is 7.249597778869266 MeV
The binding energy for an atom with atomic number 78 is maximized when its mass number is: 164
The corresponding binding energy per nucleon is 7.22310245870899 MeV
The binding energy for an atom with atomic number 79 is maximized when its mass number is: 165
The corresponding binding energy per nucleon is 7.188712895456172 MeV
The binding energy for an atom with atomic number 80 is maximized when its mass number is: 168
The corresponding binding energy per nucleon is 7.163577218102271 MeV
The binding energy for an atom with atomic number 81 is maximized when its mass number is: 169
The corresponding binding energy per nucleon is 7.127258348007435 MeV
The binding energy for an atom with atomic number 82 is maximized when its mass number is: 172
The corresponding binding energy per nucleon is 7.10339061133681 MeV
The binding energy for an atom with atomic number 83 is maximized when its mass number is: 173
The corresponding binding energy per nucleon is 7.065304351415036 MeV
The binding energy for an atom with atomic number 84 is maximized when its mass number is: 176
The corresponding binding energy per nucleon is 7.042620612142927 MeV
The binding energy for an atom with atomic number 85 is maximized when its mass number is: 179
The corresponding binding energy per nucleon is 7.005622315941091 MeV
The binding energy for an atom with atomic number 86 is maximized when its mass number is: 180
The corresponding binding energy per nucleon is 6.981336598852258 MeV
The binding energy for an atom with atomic number 87 is maximized when its mass number is: 183
The corresponding binding energy per nucleon is 6.945898605341501 MeV
The binding energy for an atom with atomic number 88 is maximized when its mass number is: 184
```
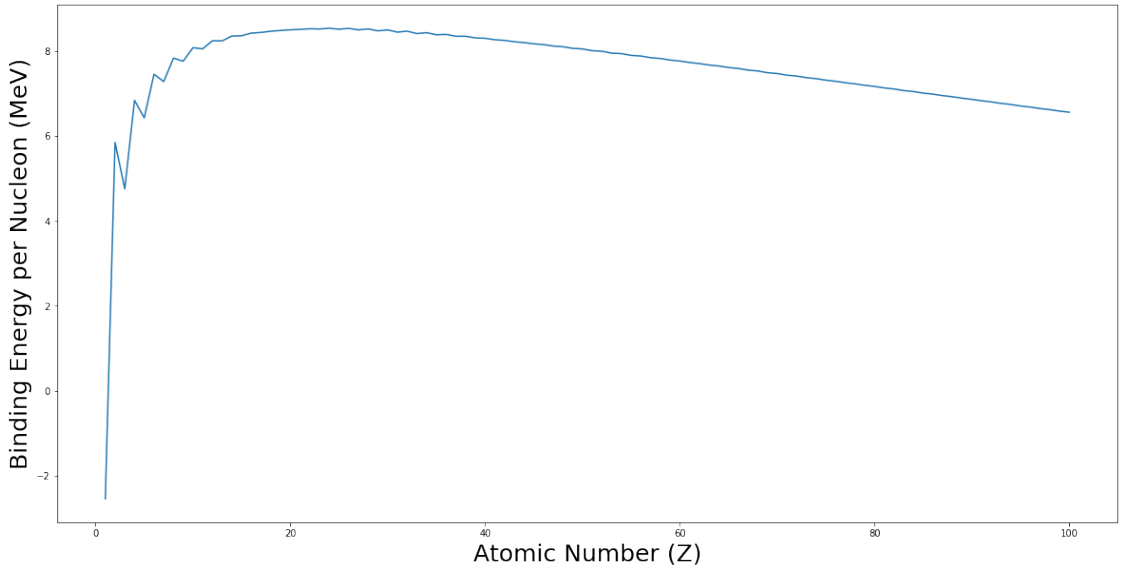

```
The corresponding binding energy per nucleon is 6.919600438263286 MeV
The binding energy for an atom with atomic number 89 is maximized when its mass number is: 187
The corresponding binding energy per nucleon is 6.885629827659542 MeV
The binding energy for an atom with atomic number 90 is maximized when its mass number is: 190
The corresponding binding energy per nucleon is 6.857606054313791 MeV
The binding energy for an atom with atomic number 91 is maximized when its mass number is: 191
The corresponding binding energy per nucleon is 6.824878368299097 MeV
The binding energy for an atom with atomic number 92 is maximized when its mass number is: 194
The corresponding binding energy per nucleon is 6.7980284984155 MeV
The binding energy for an atom with atomic number 93 is maximized when its mass number is: 195
The corresponding binding energy per nucleon is 6.763700169837886 MeV
The binding energy for an atom with atomic number 94 is maximized when its mass number is: 198
The corresponding binding energy per nucleon is 6.737957421244245 MeV
The binding energy for an atom with atomic number 95 is maximized when its mass number is: 199
The corresponding binding energy per nucleon is 6.702145489317908 MeV
The binding energy for an atom with atomic number 96 is maximized when its mass number is: 202
The corresponding binding energy per nucleon is 6.677447887170413 MeV
The binding energy for an atom with atomic number 97 is maximized when its mass number is: 205
The corresponding binding energy per nucleon is 6.641488369559367 MeV
The binding energy for an atom with atomic number 98 is maximized when its mass number is: 206
The corresponding binding energy per nucleon is 6.616549516348999 MeV
The binding energy for an atom with atomic number 99 is maximized when its mass number is: 209
The corresponding binding energy per nucleon is 6.5818849352304305 MeV
The binding energy for an atom with atomic number 100 is maximized when its mass number is: 210
The corresponding binding energy per nucleon is 6.5553070954027755 MeV
The maximum binding energy per nucleon is 8.532622751365931 MeV.
From the list above we can see that this corresponds to Z=24
```

1.1.3 Part (c)

```
In [3]: %matplotlib inline
        import matplotlib.pyplot as plt
        import numpy as np
        from math import *

        #Creating a list that contains the atomic numbers of interest.
        AtomicNumberList=np.arange(1,101)
        #Creating a list that contains zeros.
        MaxBindingEnergyPerNucleonList=np.zeros(100)
        #Going through all the atomic numbers of interest.
        for m in range(100):
            #Creating a list that contains zeros.
            BindingEnergyPerNucleonList=np.zeros(3*AtomicNumberList[m]-AtomicNumberList[m]+1)
            #Counter to run though the BindingEnergyPerNucleonList list.
            l=0
            #First four liquid drop model constants.
            a1 = 15.67
```

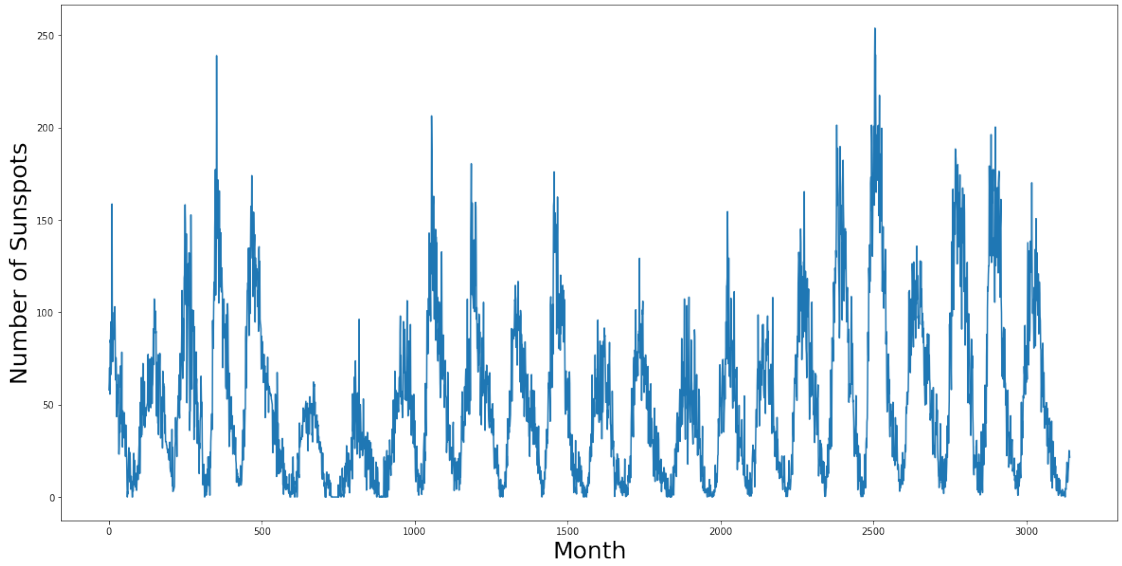
```
        a2 = 17.23
        a3 = 0.75
        a4 = 93.2
        #Ranging mass number
        for A in range(AtomicNumberList[m], 3*AtomicNumberList[m]+1):
            #Fifth liquid drop model constant.
            if A%2!=0:
                a5=0.
            elif A%2==0 and AtomicNumberList[m]%2==0:
                a5=12.
            elif A%2==0 and AtomicNumberList[m]%2!=0:
                a5=-12.
            #Calculation of binding energy per nucleon for a given mass number A.
            BE=(a1*A)-(a2*A**(2./3.))-(a3*(AtomicNumberList[m]**2.)/(A**(1./3.)))-\
            ((a4*(A-2.*AtomicNumberList[m])**2.)/A)+(a5/(A**(1./2.)))
            BEPN=BE/A
            #Filling up the BindingEnergyPerNucleonList list.
            BindingEnergyPerNucleonList[l]=BEPN
            #Finding the maximum binding energy per nucleon for the given mass number A.
            if BEPN==BindingEnergyPerNucleonList.max():
                MaxMassNumber=A
            if AtomicNumberList[m]==1:
                MaxMassNumber=2
            l+=1
        MaxBEPN=BindingEnergyPerNucleonList.max()
        #Collecting the values for the maximum binding energies per nucleon for every A.
        MaxBindingEnergyPerNucleonList[m]=MaxBEPN
    #Plotting the maximum binding energy per nucleon
    #as a function of atomic number Z and exporting the graph.
    width,height=20,10
    plt.figure(figsize=(width,height))
    plt.xlabel("Atomic Number (Z)",fontsize = 25)
    plt.ylabel("Binding Energy per Nucleon (MeV)", fontsize = 25)
    plt.plot(AtomicNumberList,MaxBindingEnergyPerNucleonList)
    plt.savefig("HW2_Problem1_PartC.jpg")
```



1.2 Problem 2

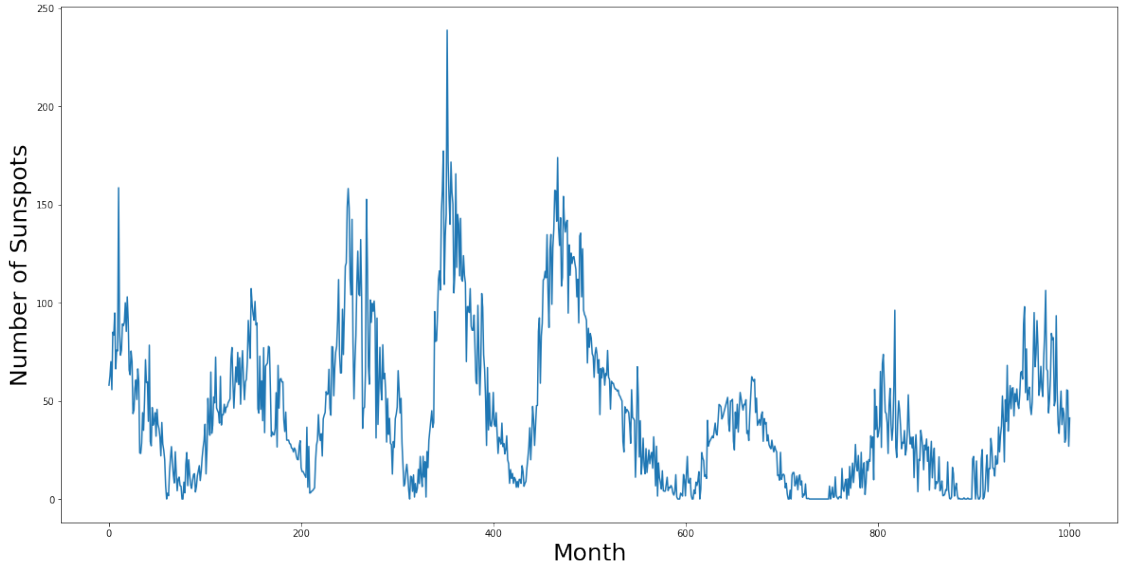
1.2.1 Part (a)

```
In [4]: %matplotlib inline
        import matplotlib.pyplot as plt
        import numpy as np
        from math import *

        #Loading data from 'sunspots.txt' file as an array.
        SunspotDataArray=np.loadtxt('sunspots.txt')
        #Creating a list that contains the month data.
        MonthData=SunspotDataArray[:,0]
        #Creating a list that contains the number of sunspots data.
        NumberOfSunspotsData=SunspotDataArray[:,1]
        #Plotting and exporting the sunspots data.
        width,height=20,10
        plt.figure(figsize=(width, height))
        plt.xlabel("Month",fontsize = 25)
        plt.ylabel("Number of Sunspots",fontsize = 25)
        plt.plot(MonthData,NumberOfSunspotsData)
        plt.savefig("HW2_Problem2_PartA.jpg")
```



1.2.2 Part (b)

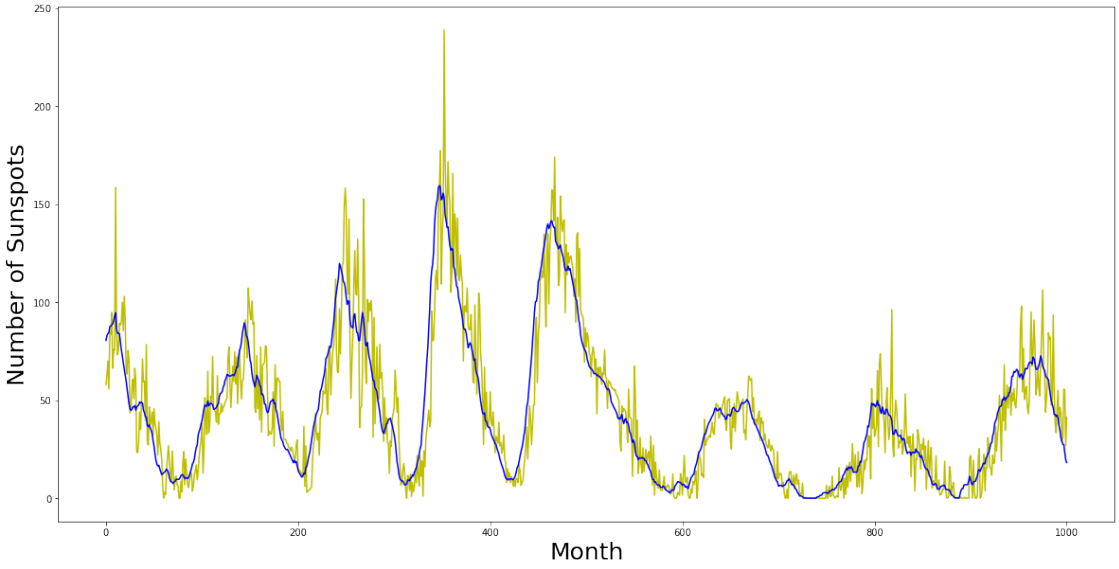
```
In [5]: %matplotlib inline
        import matplotlib.pyplot as plt
        import numpy as np
        from math import *

        #Loading data from 'sunspots.txt' file as an array.
        SunspotDataArray=np.loadtxt('sunspots.txt')
        #Creating a list that contains the month data.
        MonthData=SunspotDataArray[:,0]
        #Creating a list that contains the number of sunspots data.
        NumberOfSunspotsData=SunspotDataArray[:,1]
        #Plotting the sunspots data.
        width,height=20,10
        plt.figure(figsize=(width, height))
        plt.xlabel("Month",fontsize = 25)
        plt.ylabel("Number of Sunspots",fontsize = 25)
        plt.plot(MonthData[:1001],NumberOfSunspotsData[:1001])
        plt.savefig("HW2_Problem2_PartB.jpg")
```



1.2.3 Part (c)

```
In [4]: %matplotlib inline
        import matplotlib.pyplot as plt
        import numpy as np
        from math import *

        #Loading data from 'sunspots.txt' file as an array.
        SunspotDataArray=np.loadtxt('sunspots.txt')
        #Creating a list that contains the month data.
        MonthData=SunspotDataArray[:,0]
        #Creating a list that contains the number of sunspots data.
        NumberOfSunspotsData=SunspotDataArray[:,1]
        #r constant.
        r=5
        #Creating a list to store the running average values.
        RunningAverageList=np.zeros(NumberOfSunspotsData.size)
        l=0
        for m in range(r,1001+r):
            yk=np.sum(NumberOfSunspotsData[m-r:m+r+1])
            Yk=yk/(2*r+1)
            RunningAverageList[l]=Yk
            l+=1
        #Plotting and exporting the sunspots data.
        width,height=20,10
        plt.figure(figsize=(width, height))
        plt.plot(MonthData[:1001],NumberOfSunspotsData[0:1001],c='y',ls='-',label='Data')
        plt.plot(MonthData[:1001],RunningAverageList[:1001],c='b',ls='-',label='Running Mean')
```

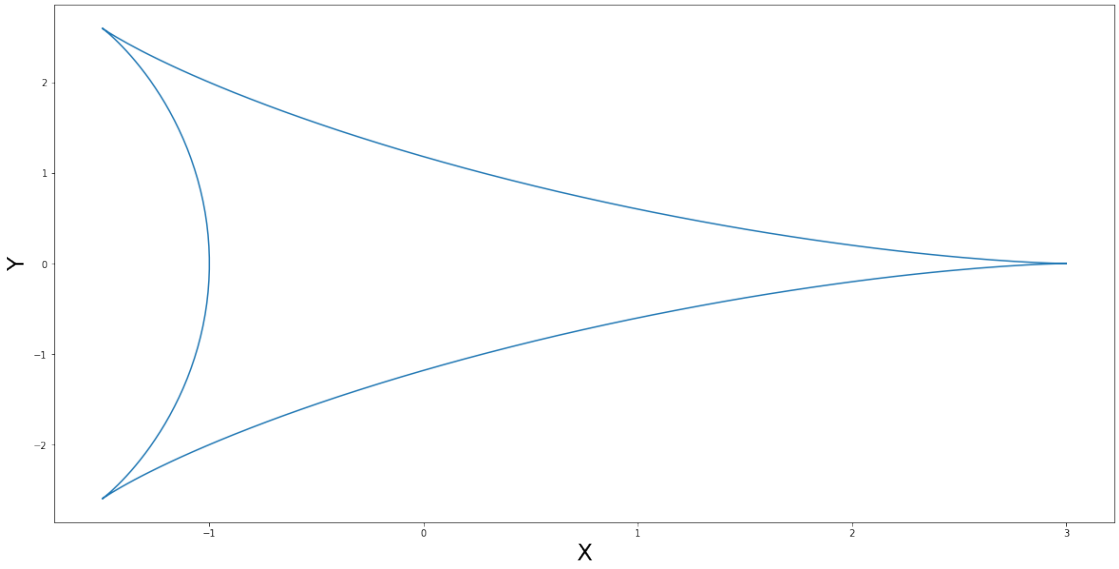
```
plt.xlabel("Month",fontsize = 25)
plt.ylabel("Number of Sunspots",fontsize = 25)
plt.savefig("HW2_Problem2_PartC.jpg")
```



1.3 Problem 3

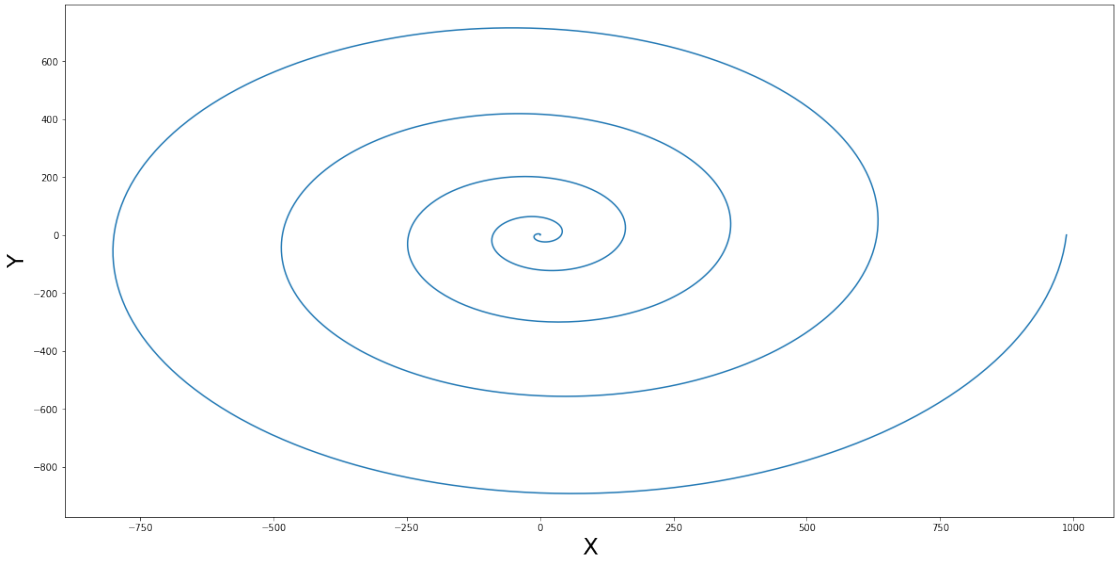
1.3.1 Part (a)

```
In [7]: %matplotlib inline
        import matplotlib.pyplot as plt
        import numpy as np
        from math import *

        #Creation of the list that contains the values of angle .
        Th=np.linspace(0,2*np.pi,200)
        #Creation of the lists that contain the parametric values of x and y as functions of .
        X=2*np.cos(Th)+np.cos(2*Th)
        Y=2*np.sin(Th)-np.sin(2*Th)
        #Plotting and exporting the corresponding curve.
        width,height=20,10
        plt.figure(figsize=(width, height))
        plt.xlabel("X",fontsize = 25)
        plt.ylabel("Y",fontsize = 25)
        plt.plot(X,Y)
        plt.savefig("HW2_Problem3_PartA.jpg")
```



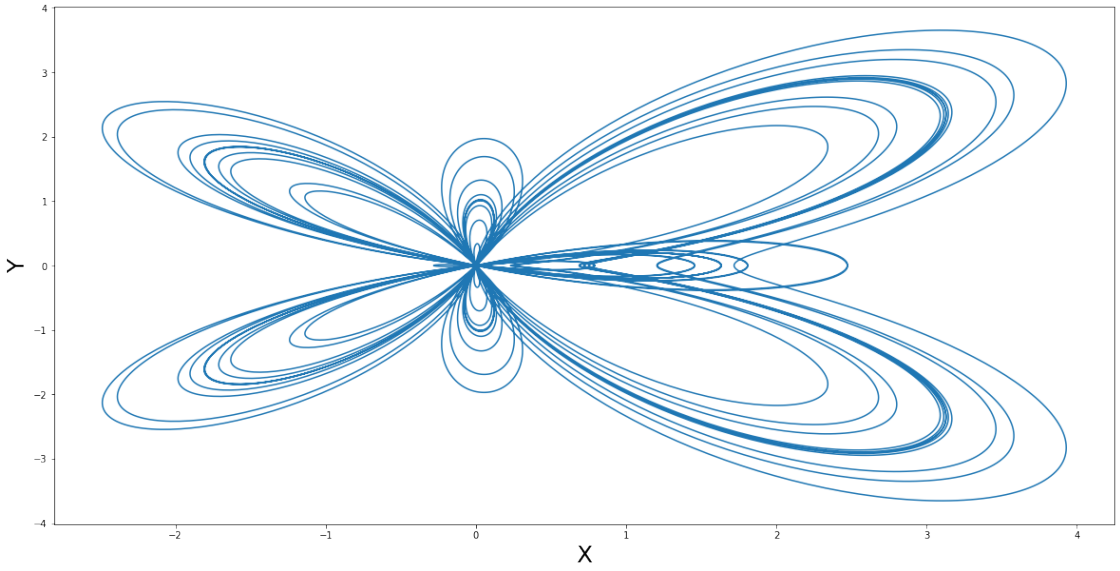
1.3.2 Part (b)

```
In [8]: %matplotlib inline
        import matplotlib.pyplot as plt
        import numpy as np
        from math import *

        #Creation of the list that contains the values of angle .
        Th=np.linspace(0,10*np.pi,1000)
        #Creation of the lists that contain the parametric values of x and y as functions of .
        X=(Th**2)*np.cos(Th)
        Y=(Th**2)*np.sin(Th)
        #Plotting and exporting the corresponding curve.
        width,height=20,10
        plt.figure(figsize=(width, height))
        plt.xlabel("X",fontsize = 25)
        plt.ylabel("Y",fontsize = 25)
        plt.plot(X,Y)
        plt.savefig("HW2_Problem3_PartB.jpg")
```



1.3.3 Part (c)

```
In [9]: %matplotlib inline
        import matplotlib.pyplot as plt
        import numpy as np
        from math import *

        #Creation of the list that contains the values of angle .
        Th=np.linspace(0,24*np.pi,10000)
        #Creation of the lists that contain the parametric values of x and y as functions of .
        X=(np.e**(np.cos(Th))-2*np.cos(4*Th)+np.sin(Th/12.)**5)*np.cos(Th)
        Y=(np.e**(np.cos(Th))-2*np.cos(4*Th)+np.sin(Th/12.)**5)*np.sin(Th)
        #Plotting and exporting the corresponding curve.
        width,height=20,10
        plt.figure(figsize=(width, height))
        plt.xlabel("X",fontsize = 25)
        plt.ylabel("Y",fontsize = 25)
        plt.plot(X,Y)
        plt.savefig("HW2_Problem3_PartC.jpg")
```


Y
X
4
3
2
1
0
−1
−2
−3
−4
−2
−1
0
1
2
3
4