Scientific Computing (MA322)

Lab 02

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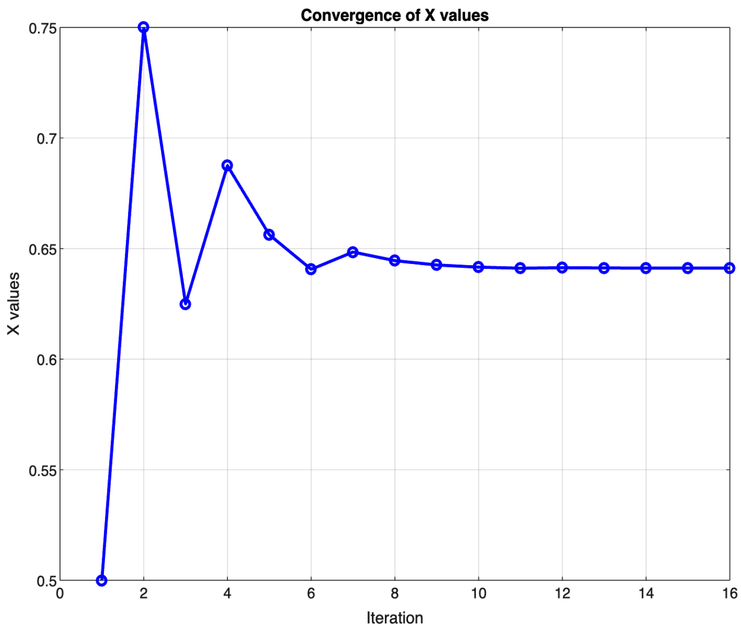
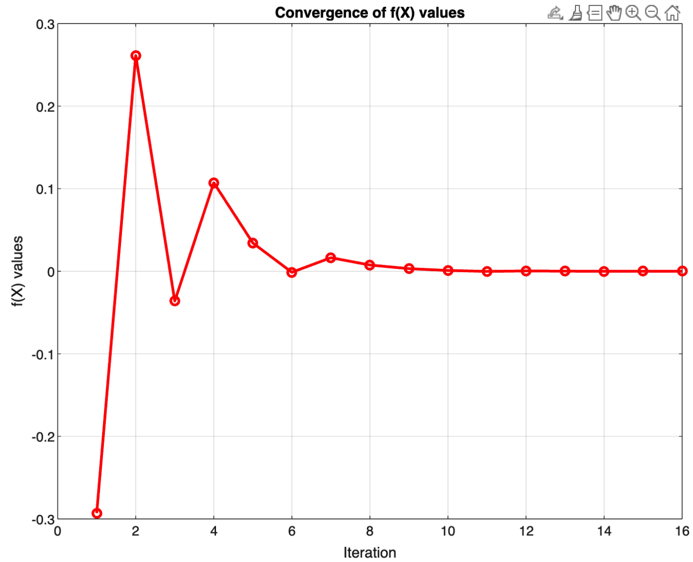
Assumption - 1)Since Real(Actual roots cannot be calculated) , I used fzero function of matlab to estimate zero of a function and used that number as base(Real root though cant be calculated)
2) In Newton's method while calculating Residues initially I assumed X0=0 and X1 to be initial approximation

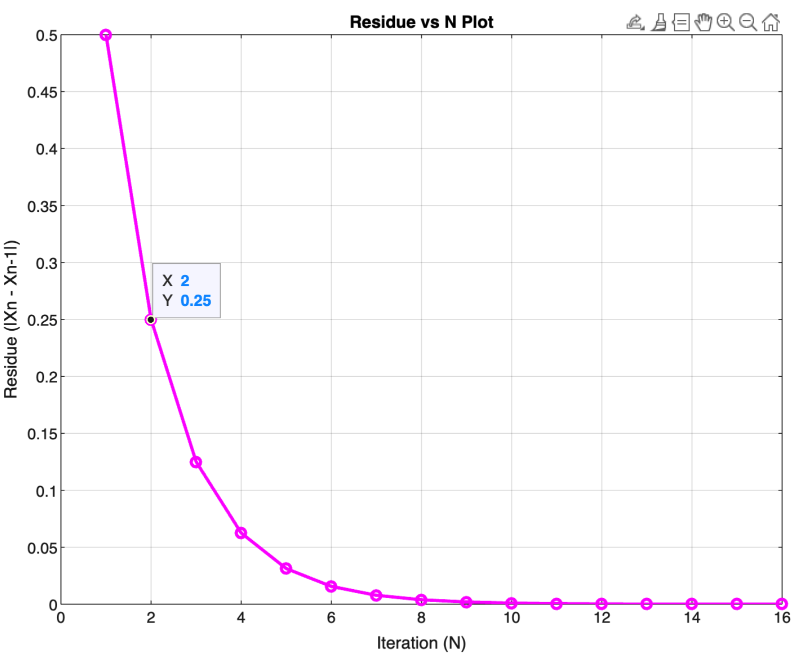
Question-1

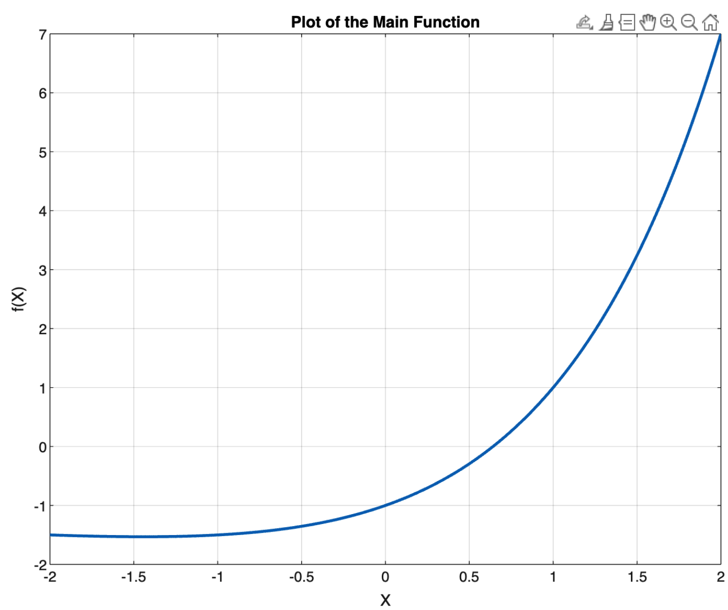
-Used epsilon as 1e-5
- Used Nmax as 10000

```
>> test
Below Values are up to 8 decimal places
Iteration       X               f(x)            Actual Solution         Absolute Error          Residue
1               0.50000000      -0.29289322     0.64118574      0.14118574              .0.500000
2               0.75000000      0.26134462      0.64118574      0.10881426              .0.250000
3               0.62500000      -0.03611823     0.64118574      0.01618574              .0.125000
4               0.68750000      0.10721210      0.64118574      0.04631426              .0.062500
5               0.65625000      0.03423743      0.64118574      0.01506426              .0.031250
6               0.64062500      -0.00126281     0.64118574      0.00056074              .0.015625
7               0.64843750      0.01640609      0.64118574      0.00725176              .0.007812
8               0.64453125      0.00755142      0.64118574      0.00334551              .0.003906
9               0.64257812      0.00313926      0.64118574      0.00139238              .0.001953
10              0.64160156      0.00093697      0.64118574      0.00041582              .0.000977
11              0.64111328      -0.00016324     0.64118574      0.00007246              .0.000488
12              0.64135742      0.00038679      0.64118574      0.00017168              .0.000244
13              0.64123535      0.00011176      0.64118574      0.00004961              .0.000122
14              0.64117432      -0.00002574     0.64118574      0.00001143              .0.000061
15              0.64120483      0.00004300      0.64118574      0.00001909              .0.000031
16              0.64118958      0.00000863      0.64118574      0.00000383              .0.000015
Approximate Solution comes out to be 0.64118958
>>
```


Convergence of X values
X values
Iteration


Convergence of f(X) values
f(X) values
Iteration

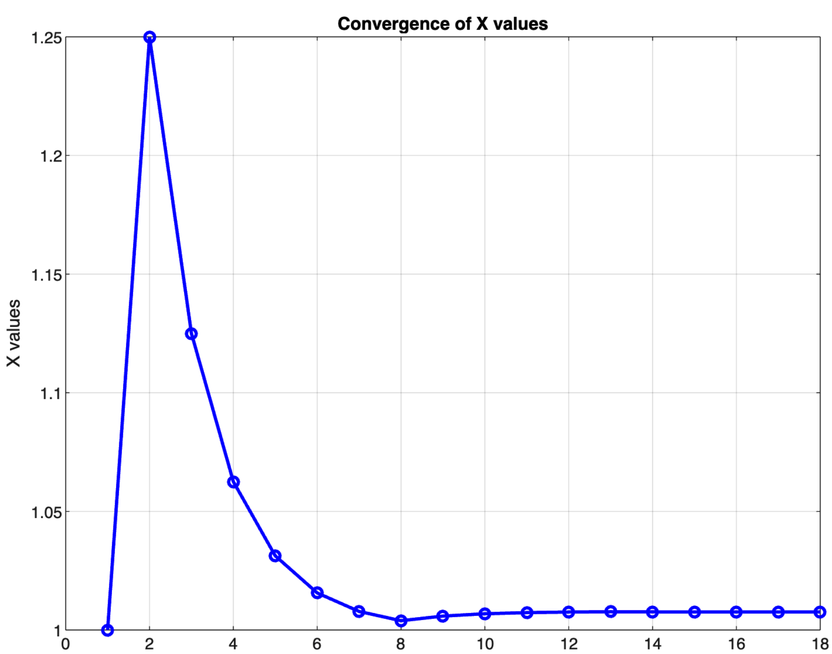

Residue vs N Plot
Residue (|Xn - Xn-1|)
Iteration (N)
X 2
Y 0.25

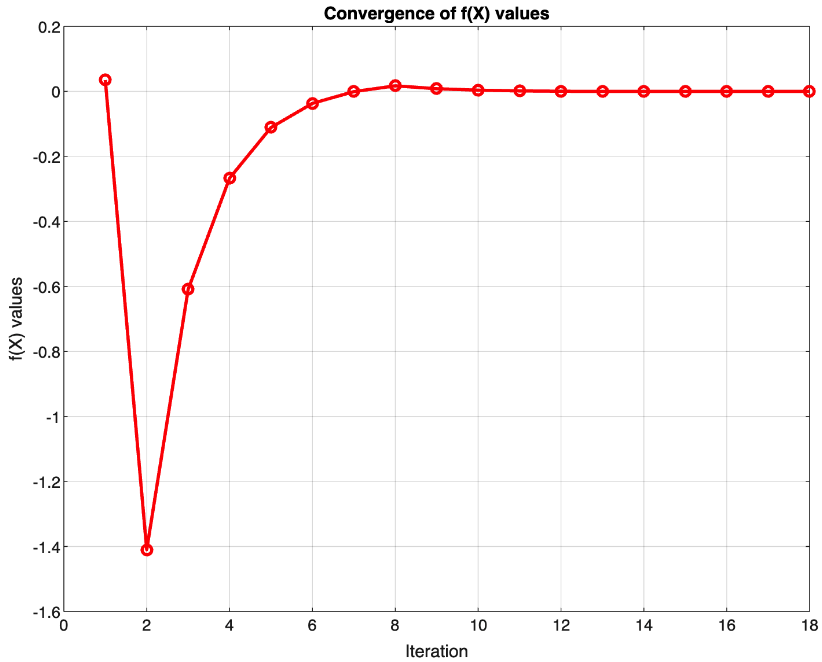

Plot of the Main Function
f(X)
X

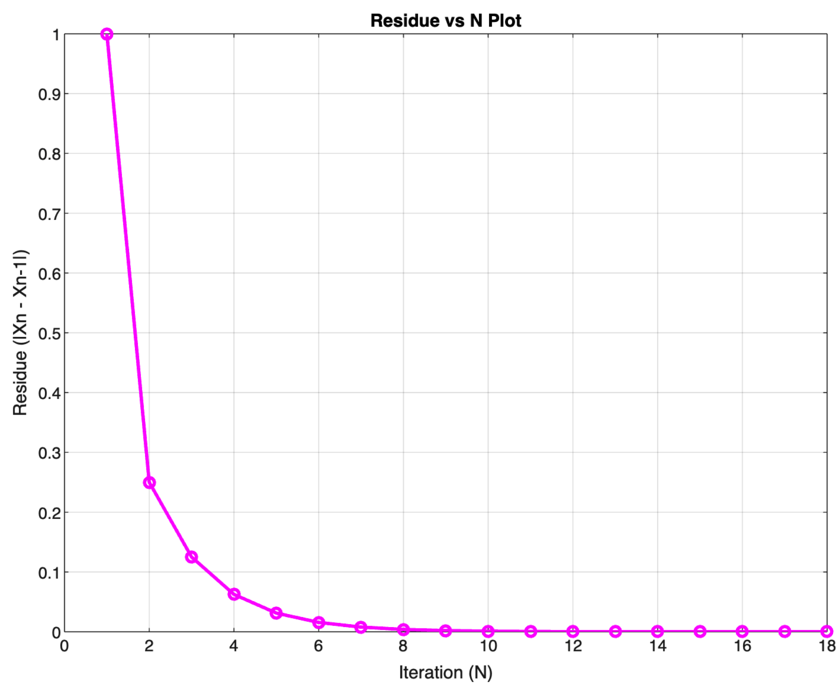
Question-2 Part A

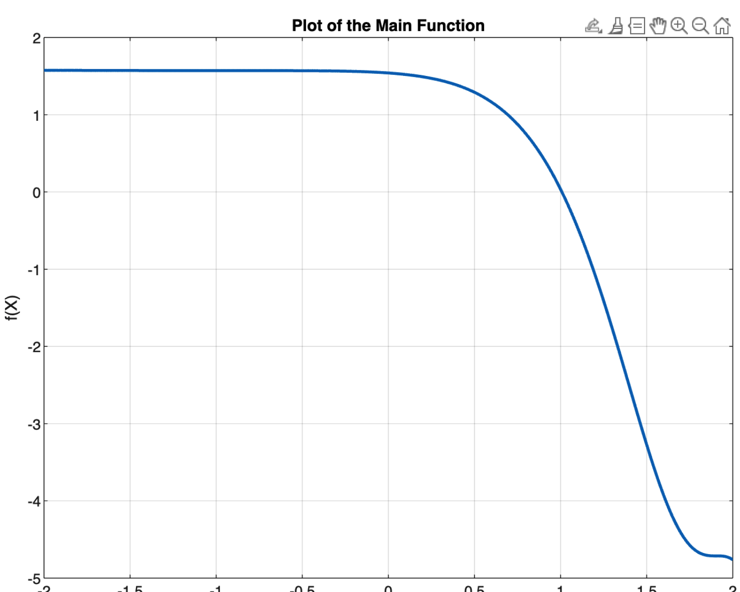
-Used epsilon as 1e-5
- Used Nmax as 10000

```
Below Values are up to 8 decimal places
Iteration       X               f(x)            Actual Solution         Absolute Error          Residue
1               1.00000000      0.03465573      1.00762397      0.00762397              1.00000000
2               1.25000000      -1.40997635     1.00762397      0.24237603              0.25000000
3               1.12500000      -0.60907975     1.00762397      0.11737603              0.12500000
4               1.06250000      -0.26698229     1.00762397      0.05487603              0.06250000
5               1.03125000      -0.11114776     1.00762397      0.02362603              0.03125000
6               1.01562500      -0.03700287     1.00762397      0.00800103              0.01562500
7               1.00781250      -0.00086443     1.00762397      0.00018853              0.00781250
8               1.00390625      0.01697272      1.00762397      0.00371772              0.00390625
9               1.00585938      0.00807344      1.00762397      0.00176460              0.00195312
10              1.00683594      0.00360933      1.00762397      0.00078803              0.00097656
11              1.00732422      0.00137366      1.00762397      0.00029975              0.00048828
12              1.00756836      0.00025492      1.00762397      0.00005561              0.00024414
13              1.00769043      -0.00030468     1.00762397      0.00006646              0.00012207
14              1.00762939      -0.00002486     1.00762397      0.00000542              0.00006104
15              1.00759888      0.00011504      1.00762397      0.00002509              0.00003052
16              1.00761414      0.00004509      1.00762397      0.00000984              0.00001526
17              1.00762177      0.00001012      1.00762397      0.00000221              0.00000763
18              1.00762558      -0.00000737     1.00762397      0.00000161              0.00000381
Approximate Solution comes out to be 1.00762558
>>
```




Convergence of f(X) values
f(X) values
Iteration
0.2
0
-0.2
-0.4
-0.6
-0.8
-1
-1.2
-1.4
-1.6
0
2
4
6
8
10
12
14
16
18


Residue vs N Plot
Residue (|Xn - Xn-1|)
Iteration (N)
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0
2
4
6
8
10
12
14
16
18


Plot of the Main Function
f(X)
2
1
0
-1
-2
-3
-4
-5

Question-2 Part B

-Used epsilon as 1e-5
- Used Nmax as 10000

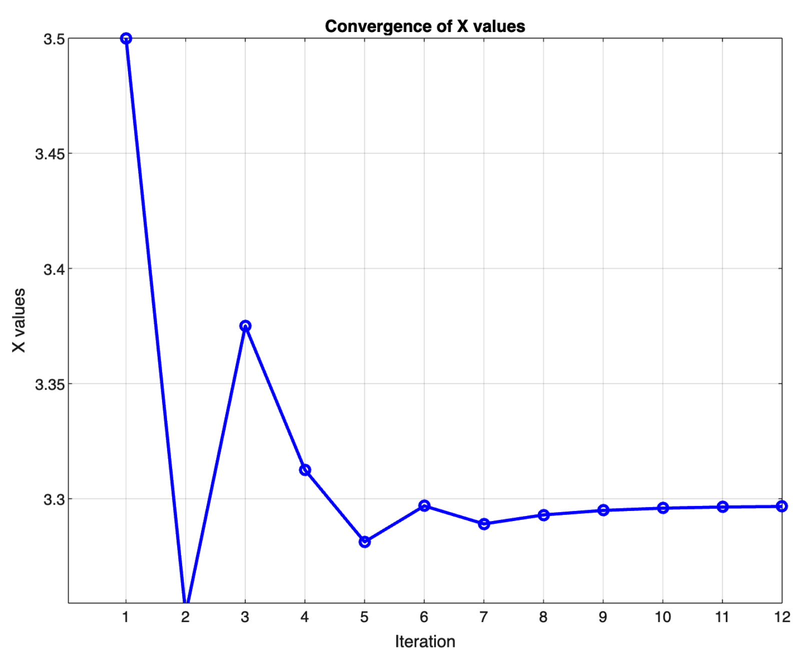
```
Below Values are up to 8 decimal places
Iteration       X               f(x)            Actual Solution         Absolute Error          Residue
Exact Solution comes out to be 0.000000
>>
```

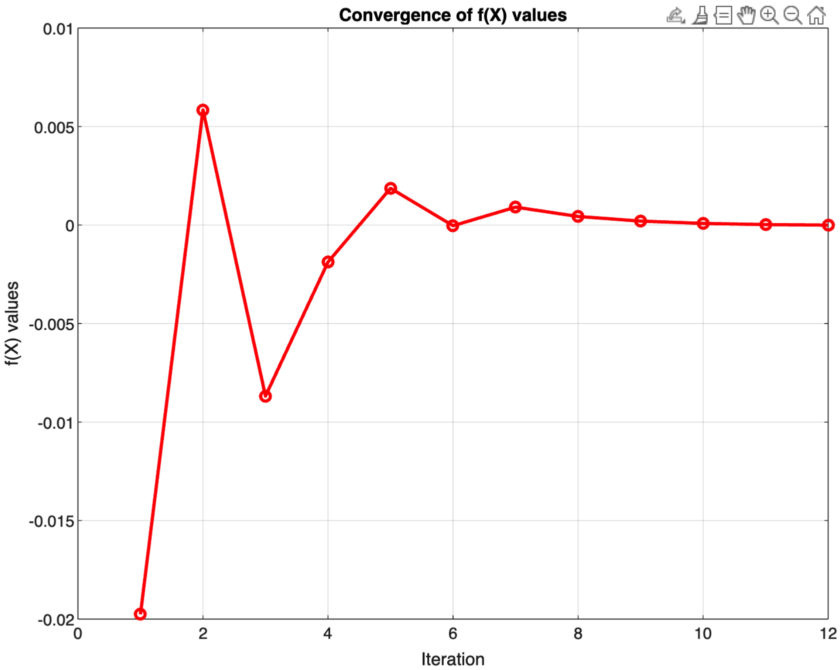
Here f(a) ie f(0) =0, Thus we get exact solution

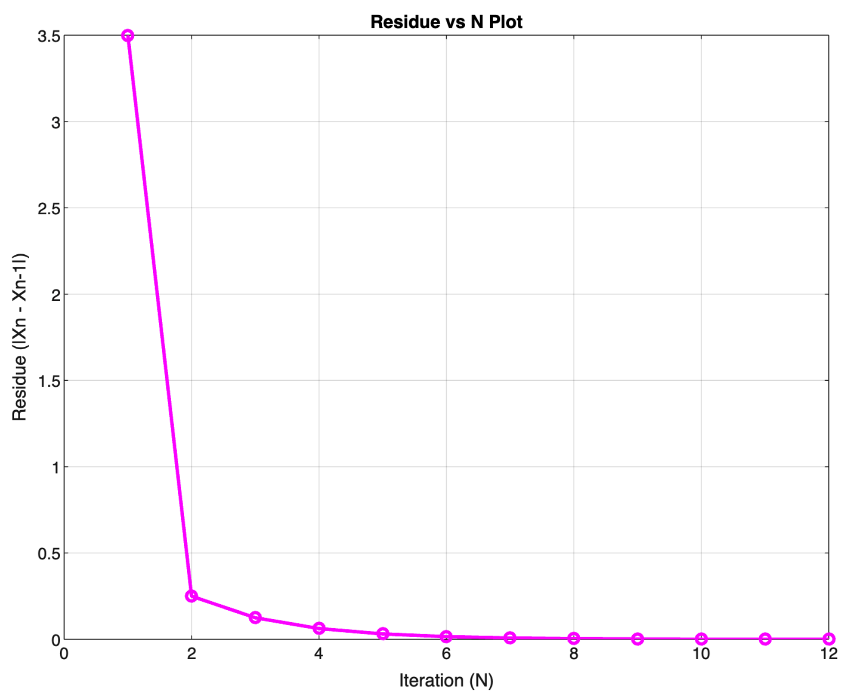
Question-2 Part C

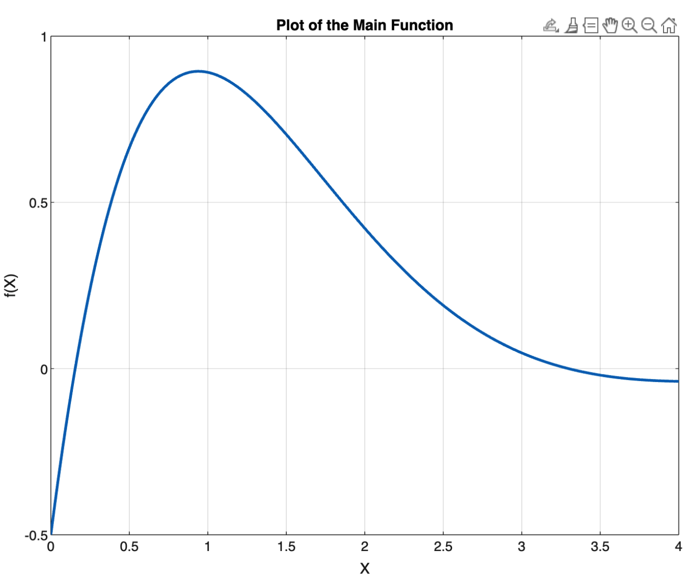
-Used epsilon as 1e-5
- Used Nmax as 10000

```
Below Values are up to 8 decimal places
Iteration       X               f(x)            Actual Solution         Absolute Error          Residue
1               3.50000000      -0.01975748     3.29658940      0.20341060              3.50000000
2               3.25000000      0.00584872      3.29658940      0.04658940              0.25000000
3               3.37500000      -0.00868108     3.29658940      0.07841060              0.12500000
4               3.31250000      -0.00187696     3.29658940      0.01591060              0.06250000
5               3.28125000      0.00186703      3.29658940      0.01533940              0.03125000
6               3.29687500      -0.00003422     3.29658940      0.00028560              0.01562500
7               3.28906250      0.00090903      3.29658940      0.00752690              0.00781250
8               3.29296875      0.00043557      3.29658940      0.00362065              0.00390625
9               3.29492188      0.00020021      3.29658940      0.00166752              0.00195312
10              3.29589844      0.00008288      3.29658940      0.00069096              0.00097656
11              3.29638672      0.00002430      3.29658940      0.00020268              0.00048828
12              3.29663086      -0.00000497     3.29658940      0.00004146              0.00024414
Approximate Solution comes out to be 3.29663086
>>
```




Convergence of f(X) values
f(X) values
Iteration
0.01
0.005
0
-0.005
-0.01
-0.015
-0.02
0
2
4
6
8
10
12

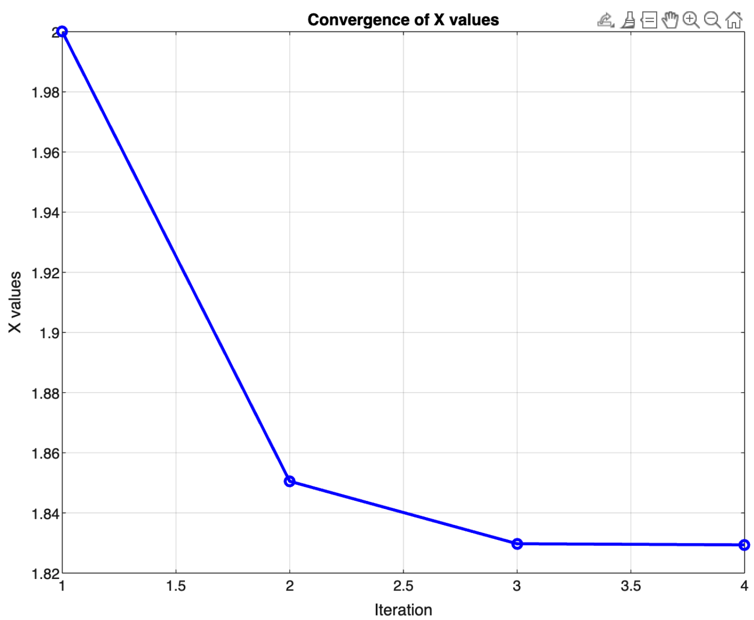

Residue vs N Plot
Residue (|Xn - Xn-1|)
Iteration (N)
3.5
3
2.5
2
1.5
1
0.5
0
0
2
4
6
8
10
12

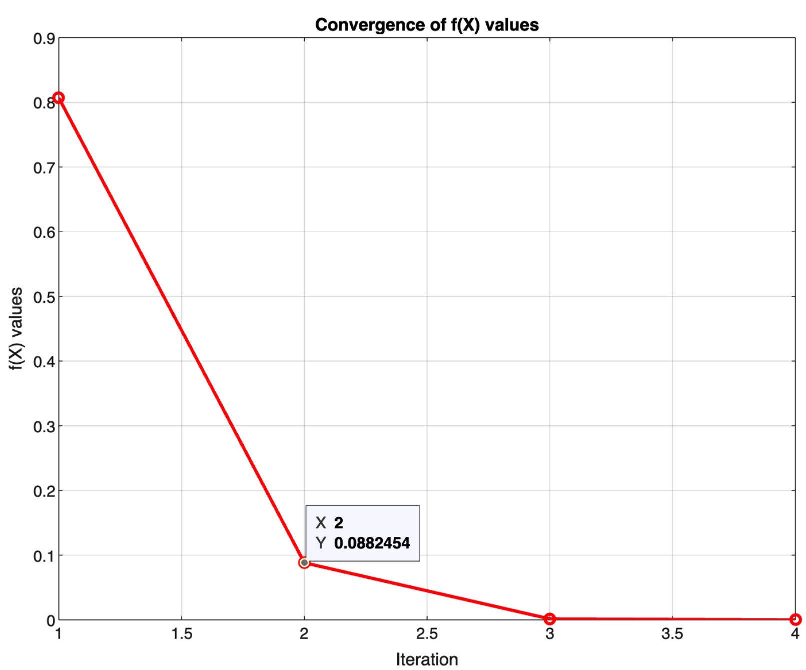

Plot of the Main Function
f(X)
X
1
0.5
0
-0.5
0
0.5
1
1.5
2
2.5
3
3.5
4

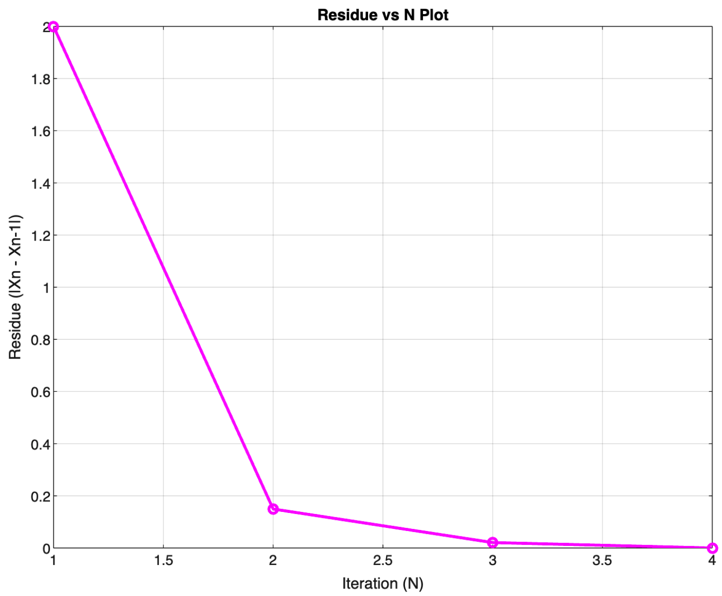
Question-3 Part A

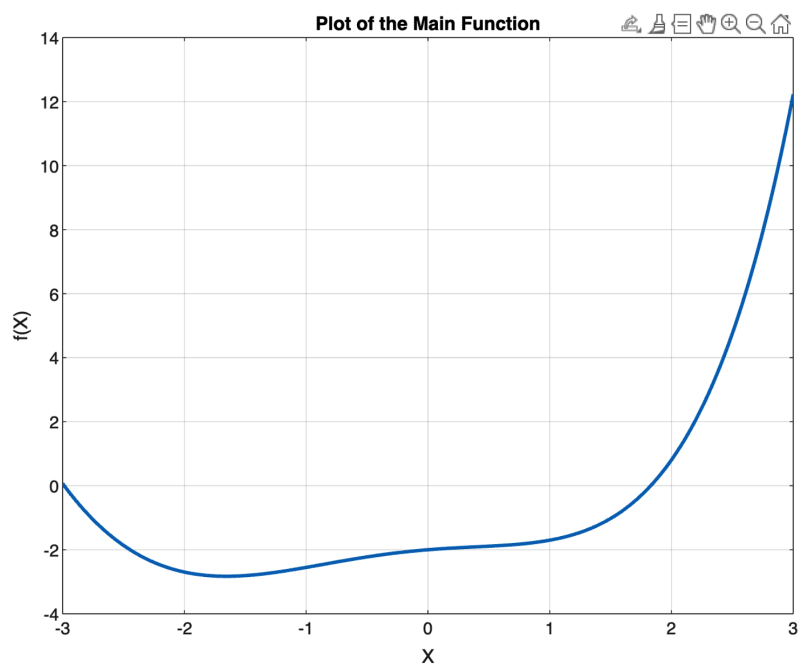
-Used epsilon as 1e-5
- Used Nmax as 10000
- initial approximation = 2

```
Below Values are up to 8 decimal places
Iteration       X               f(x)            Actual Solution         Absolute Error          Residue
1               2.00000000      0.80676243      1.82938360      0.17061640              2.00000000
2               1.85052134      0.08824542      1.82938360      0.02113773              0.14947866
3               1.82975120      0.00150818      1.82938360      0.00036760              0.02077013
4               1.82938372      0.00000046      1.82938360      0.00000011              0.00036749
Approximate Solution comes out to be 1.82938372
>>
```





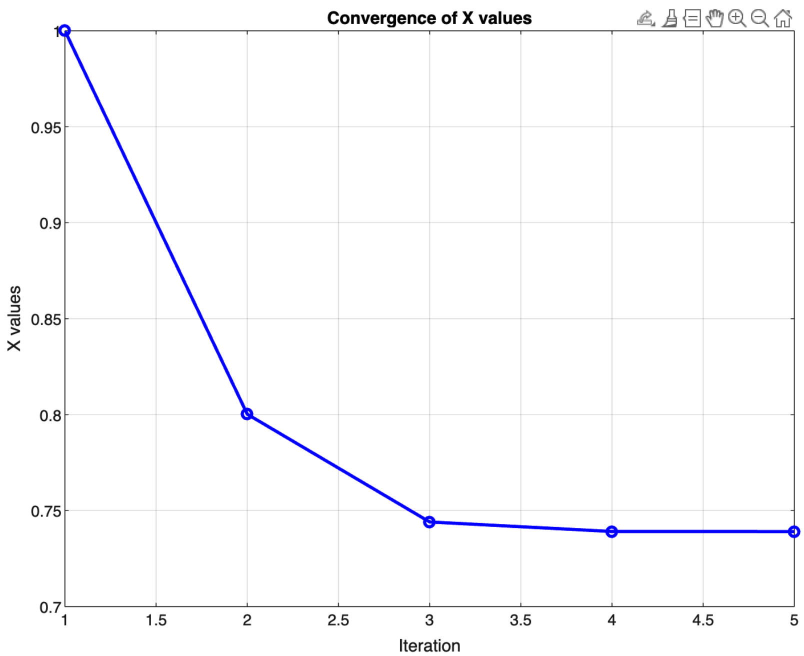


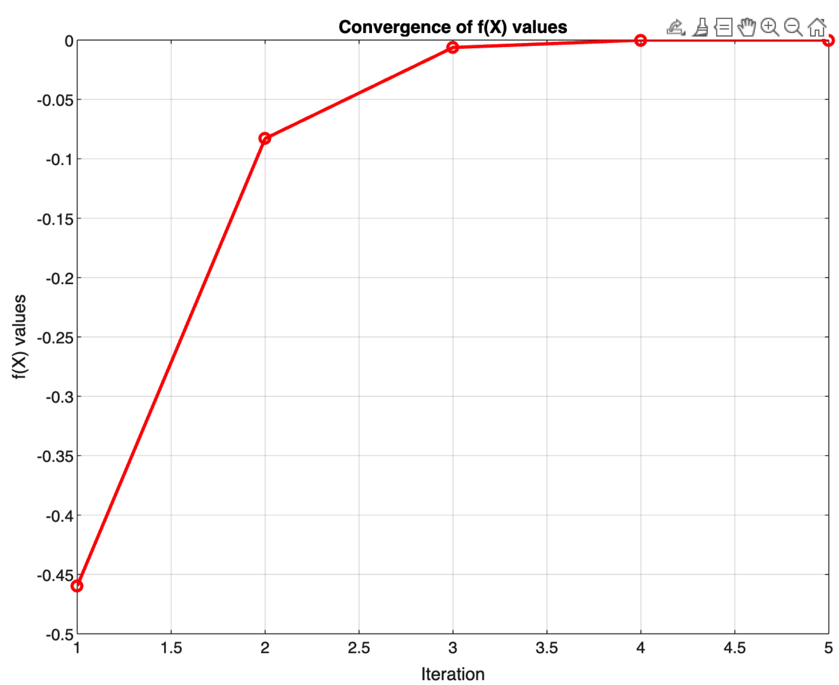


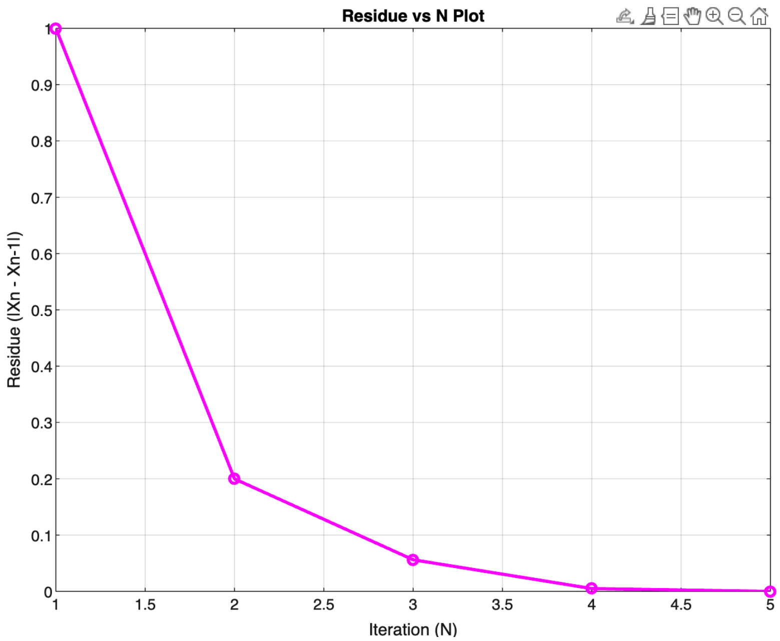
Question-3 Part B

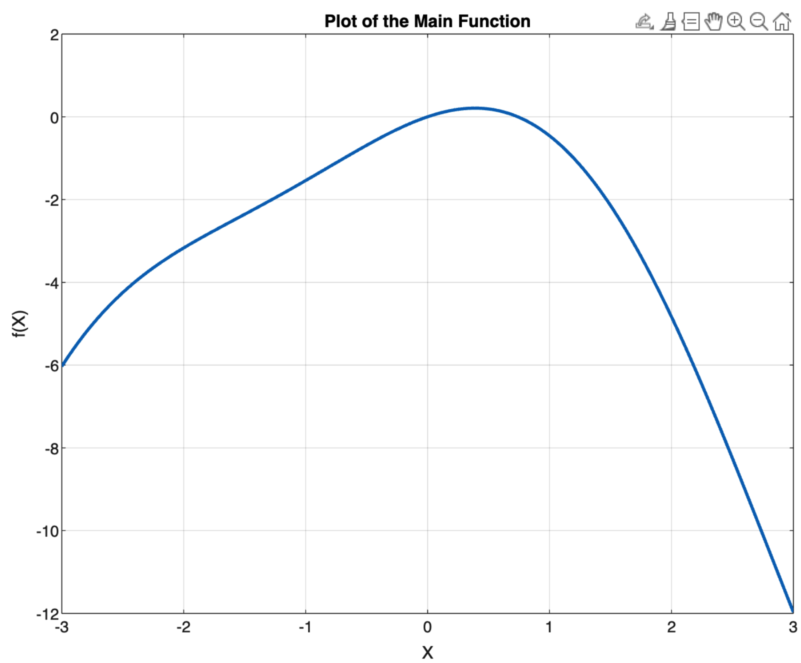
-Used epsilon as 1e-5
- Used Nmax as 10000
- initial approximation = 1

```
Below Values are up to 8 decimal places
Iteration       X               f(x)            Actual Solution         Absolute Error          Residue
1               1.00000000      -0.45969769     0.73908513      0.26091487              1.00000000
2               0.80023294      -0.08297884     0.73908513      0.06114781              0.19976706
3               0.74409440      -0.00624505     0.73908513      0.00500927              0.05613854
4               0.73912407      -0.00004816     0.73908513      0.00003894              0.00497033
5               0.73908514      -0.00000000     0.73908513      0.00000000              0.00003893
Approximate Solution comes out to be 0.73908514
>>
```





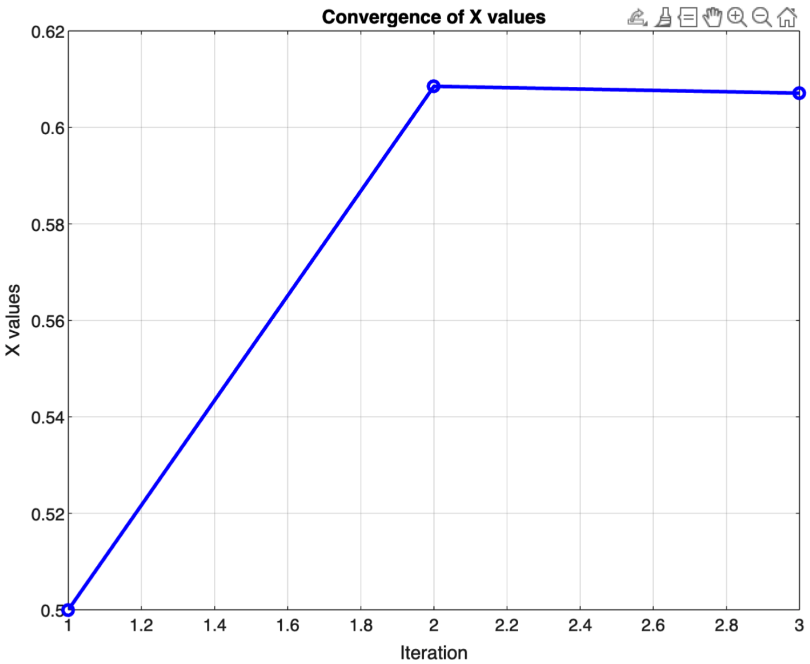


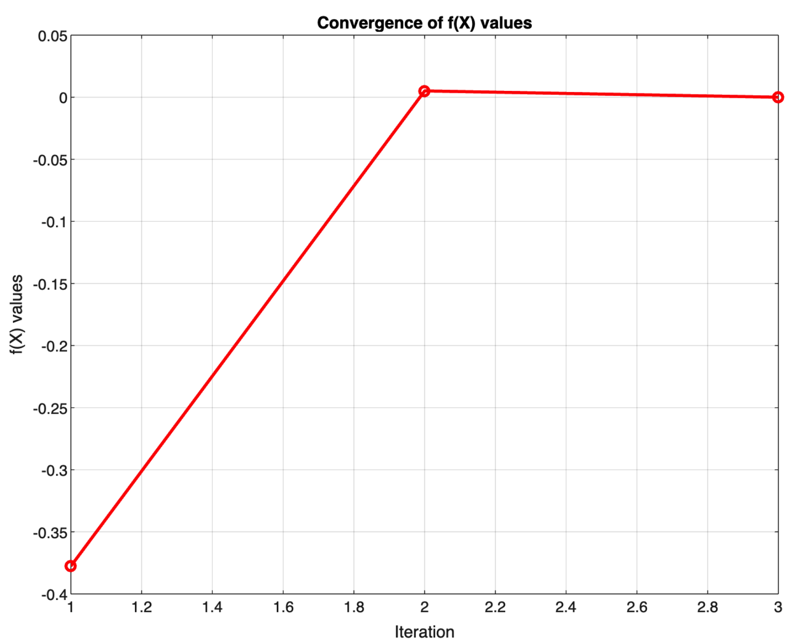


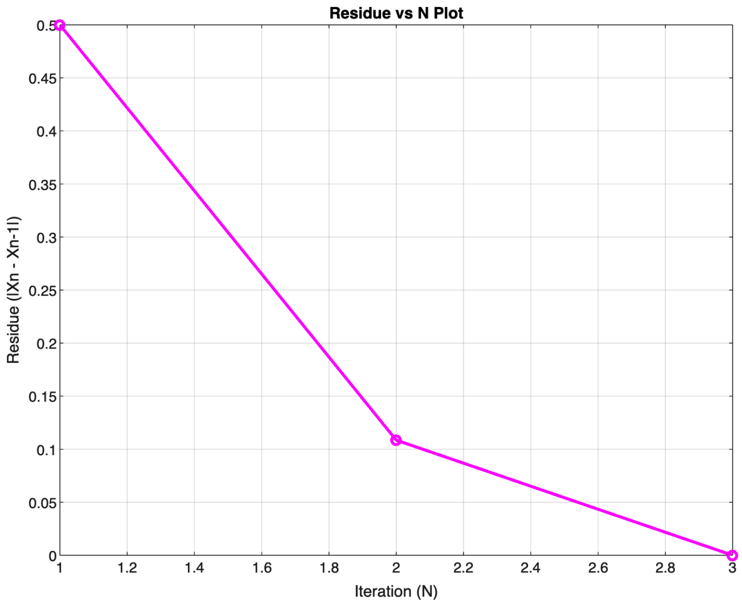
Question-3 Part C

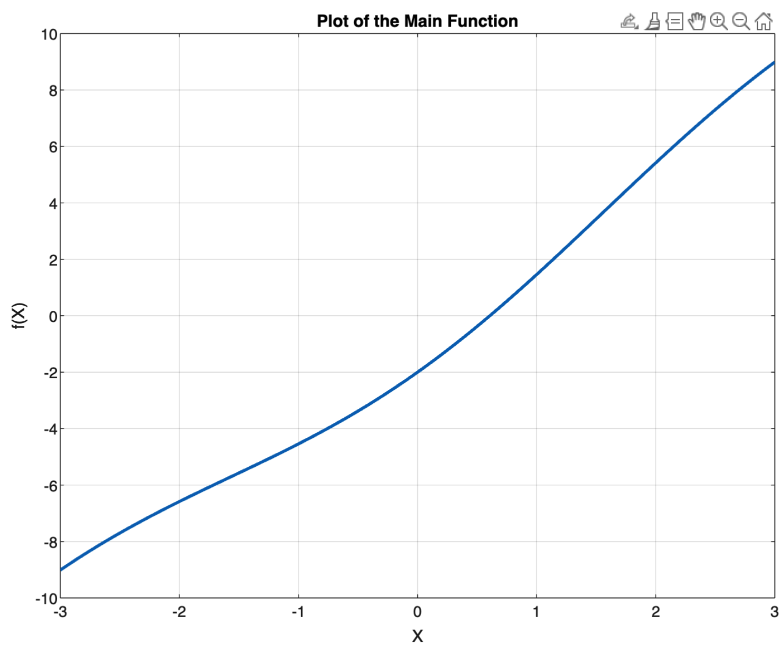
-Used epsilon as 1e-5
- Used Nmax as 10000
- initial approximation = 0.5

```
Below Values are up to 8 decimal places
Iteration       X               f(x)            Actual Solution         Absolute Error          Residue
1               0.50000000      -0.37758256     0.60710165      0.10710165              0.50000000
2               0.60851865      0.00506021      0.60710165      0.00141700              0.10851865
3               0.60710188      0.00000082      0.60710165      0.00000023              0.00141677
Approximate Solution comes out to be 0.60710188
>>
```





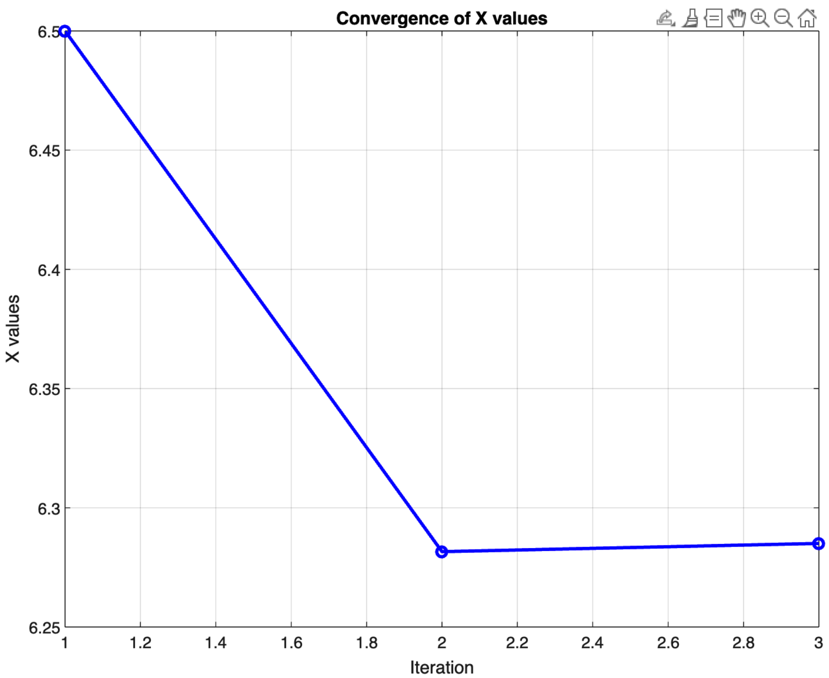


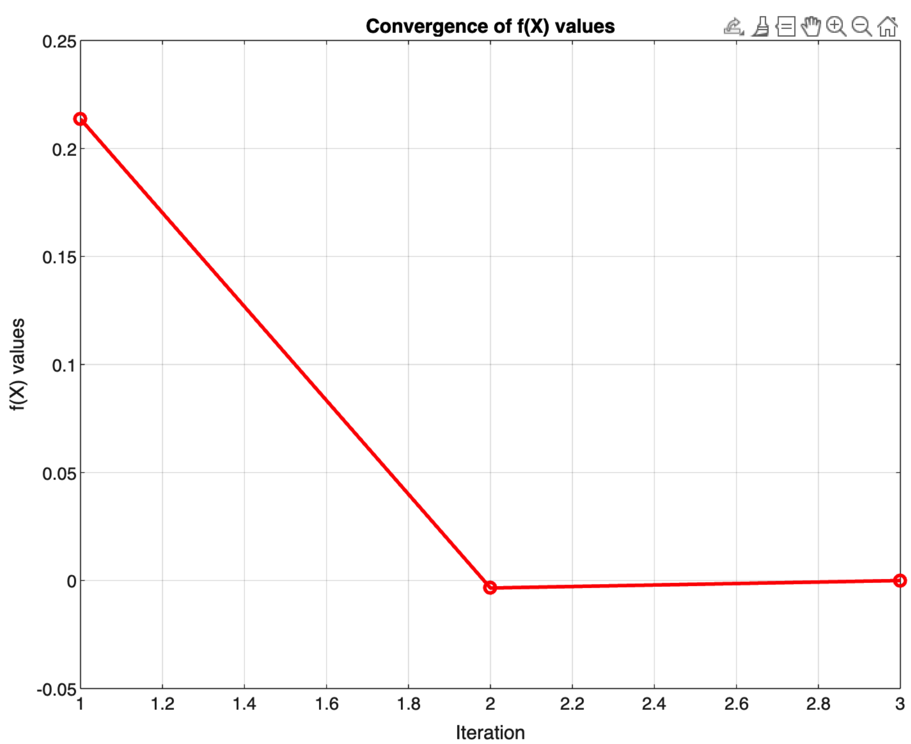


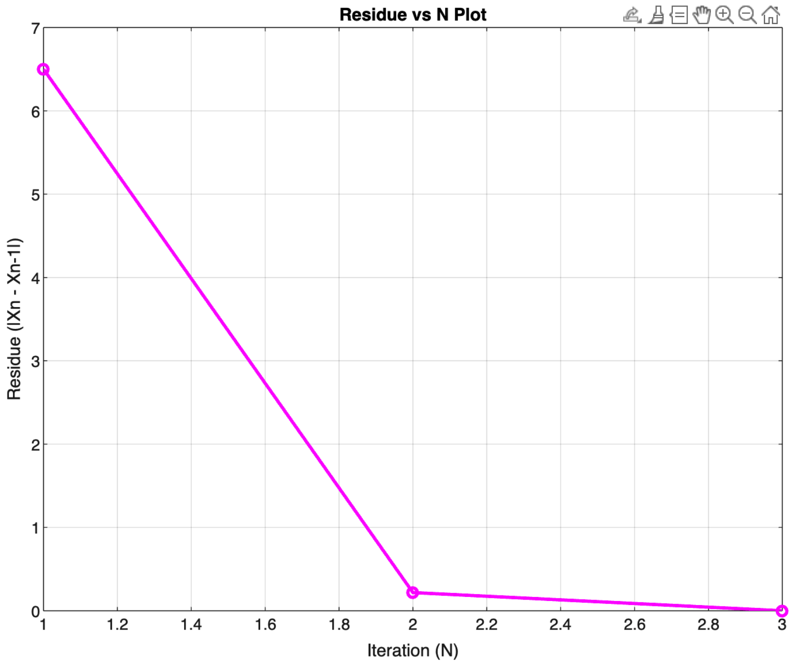
Question-3 Part D

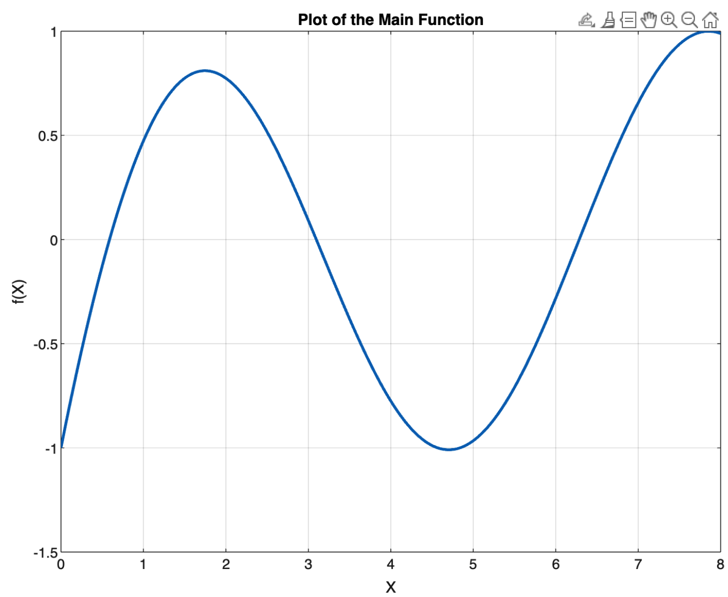
-Used epsilon as 1e-5
- Used Nmax as 10000
- initial approximation = 6.5

```
Below Values are up to 8 decimal places
Iteration       X               f(x)            Actual Solution         Absolute Error          Residue
1               6.50000000      0.21361655      6.28504927      0.21495073              6.50000000
2               6.28159851      -0.00345721     6.28504927      0.00345077              0.21840149
3               6.28504926      -0.00000001     6.28504927      0.00000001              0.00345076
Approximate Solution comes out to be 6.28504926
>> |
```









Question- 4

-Used epsilon as 1e-5
- Used Nmax as 10000
- initial approximation = 0.0001

1st approach

So when x=0.0001 then function takes value as 1/(e^(100000000)) which is very small number

The machine epsilon represents the smallest positive value that, when added to 1.0, causes a change in the resulting value within the floating-point representation of a computer. To determine the machine epsilon for your computer in MATLAB, you can utilize the 'eps' function. The computed machine epsilon for the current system is 2.2204e-16.

So clearly eps is way larger than output that our function gives us at x=0.0001, hence no matter what is the threshold, program stops in just one iteration giving us x=0.0001 value only

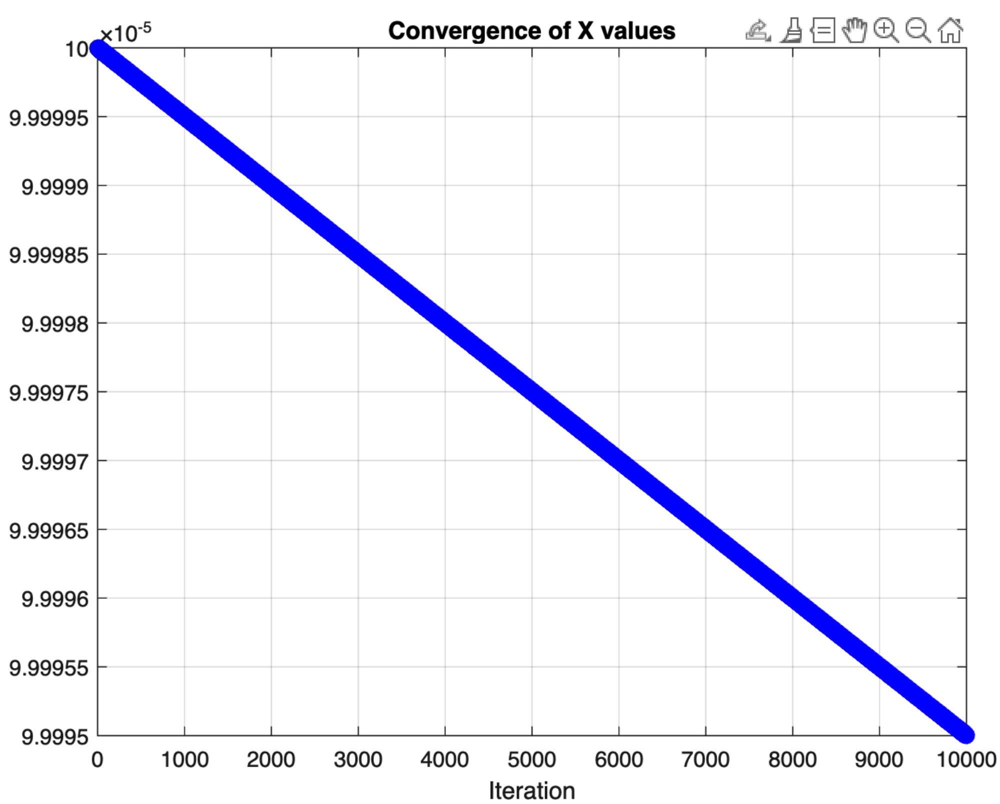
2nd approach(submitted as code)

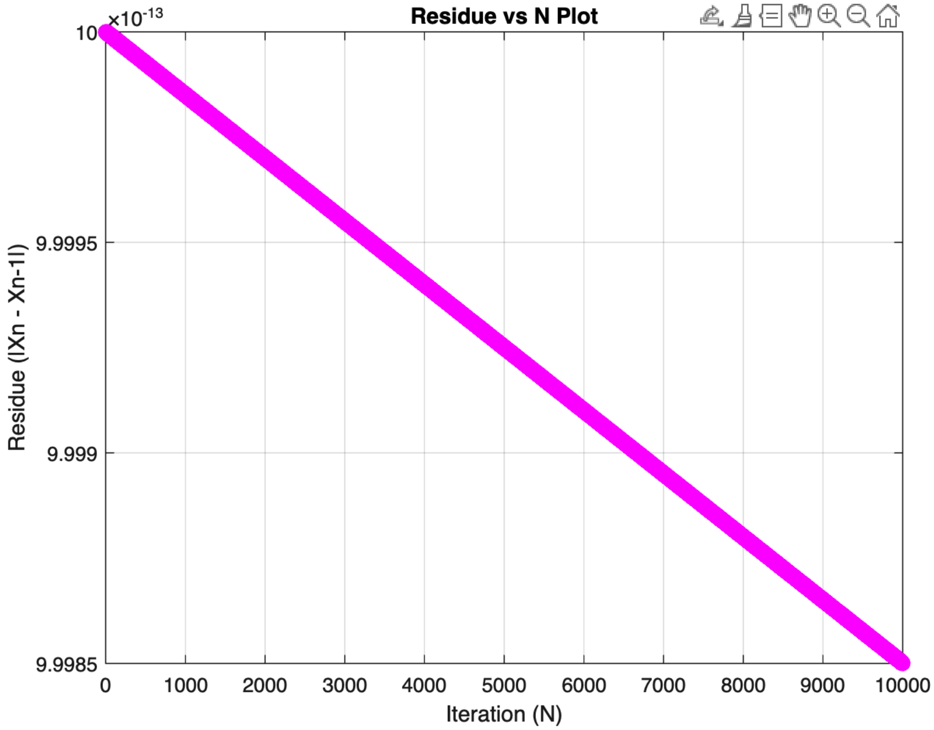
Now instead of calculating functions value at each iteration , I just substitute f(x)/f'(x) as (x^3)/2

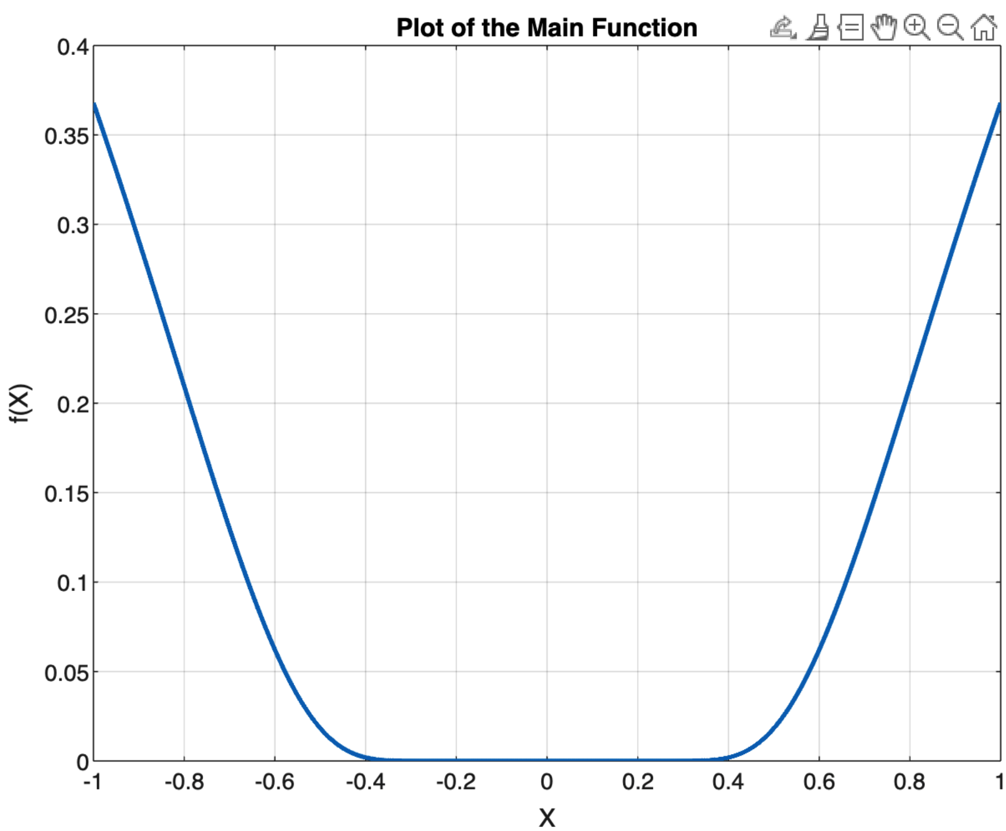
Here f(x) is e^(-1/x*x) and f'(x) is 2/(x^3) * f(x)

So finally we get Xn = Xn-1 - (Xn-1)^3/2

Now starting from X = 0.0001 And Nmax(number of iterations) as 10000




Residue vs N Plot
×10-13
10
9.9995
9.999
9.9985
Residue (|Xn - Xn-1|)
0
1000
2000
3000
4000
5000
6000
7000
8000
9000
10000
Iteration (N)


Plot of the Main Function
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
f(X)
-1
-0.8
-0.6
-0.4
-0.2
0
0.2
0.4
0.6
0.8
1
X

As we can even after 10000 iterations , Value of the iterate is 9.9995 * 10e-5 which is approximately 2 times larger than 5*10e-5 .

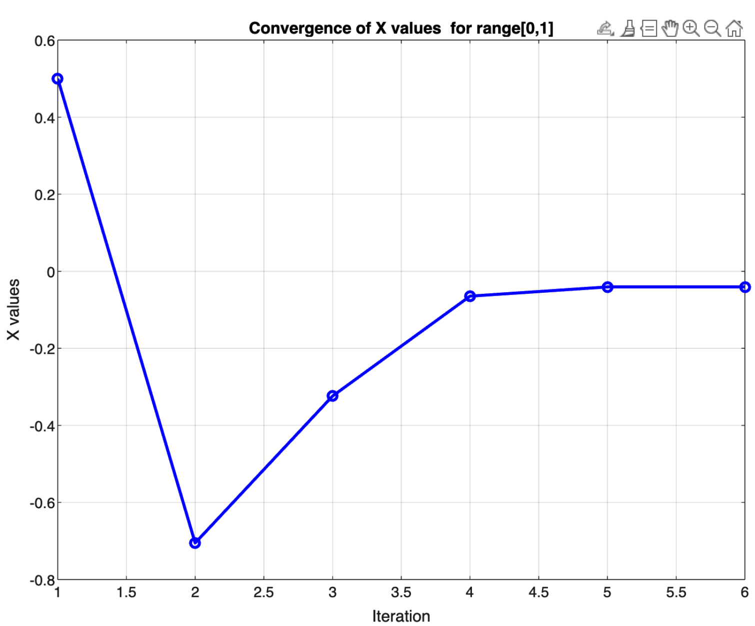
So we can conclude that Using this approach at some point value of iterate will become less than 5*10e-5 but it would require many iterations, so much so that it is computationally infeasible to run the program for that m

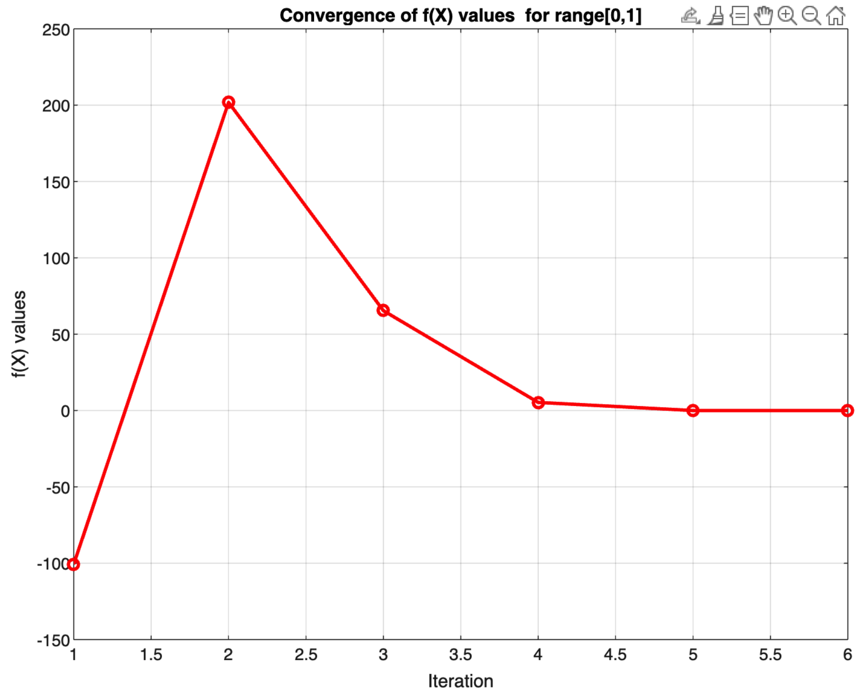
Question-5 A part Newton's Method

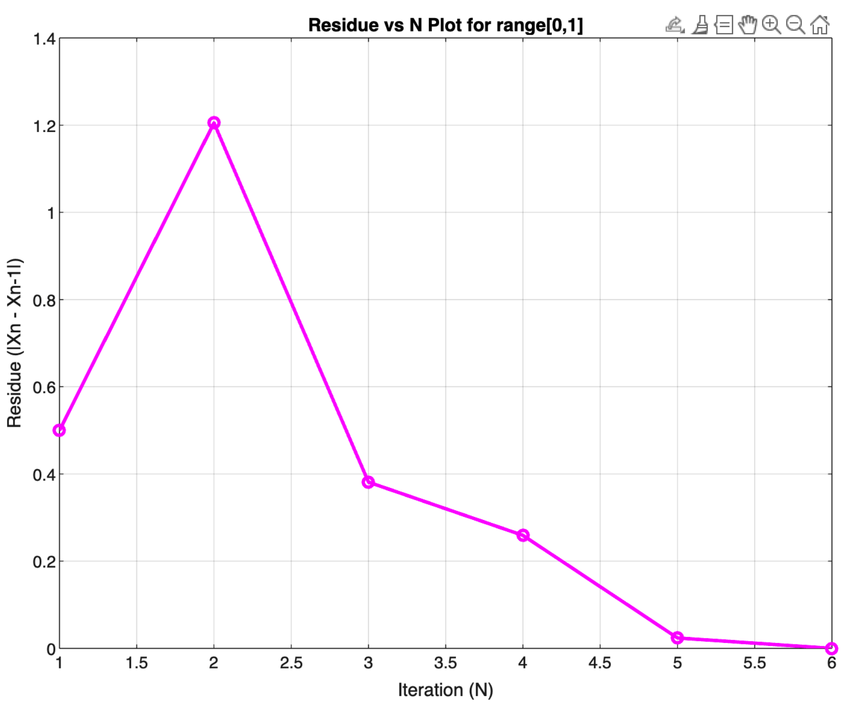
[0,1] case

-Used epsilon as 1e-6
- Used Nmax as 10000
- initial approximation = 0.5

```
Below Values are up to 8 decimal places for range [0,1] using Newtons method
Iteration       X               f(x)            Actual Solution         Absolute Error          |Xn - Xn-1|
1               0.50000000      -100.62500000   -0.04065929     0.54065929              0.50000000
2               -0.70508982     201.83630352    -0.04065929     0.66443053              1.20508982
3               -0.32379111     65.41842669     -0.04065929     0.28313183              0.38129871
4               -0.06460313     5.31400707      -0.04065929     0.02394384              0.25918798
5               -0.04068615     0.00595562      -0.04065929     0.00002686              0.02391698
6               -0.04065929     0.00000001      -0.04065929     0.00000000              0.00002686
Approximate Solution comes out to be -0.04065929
```



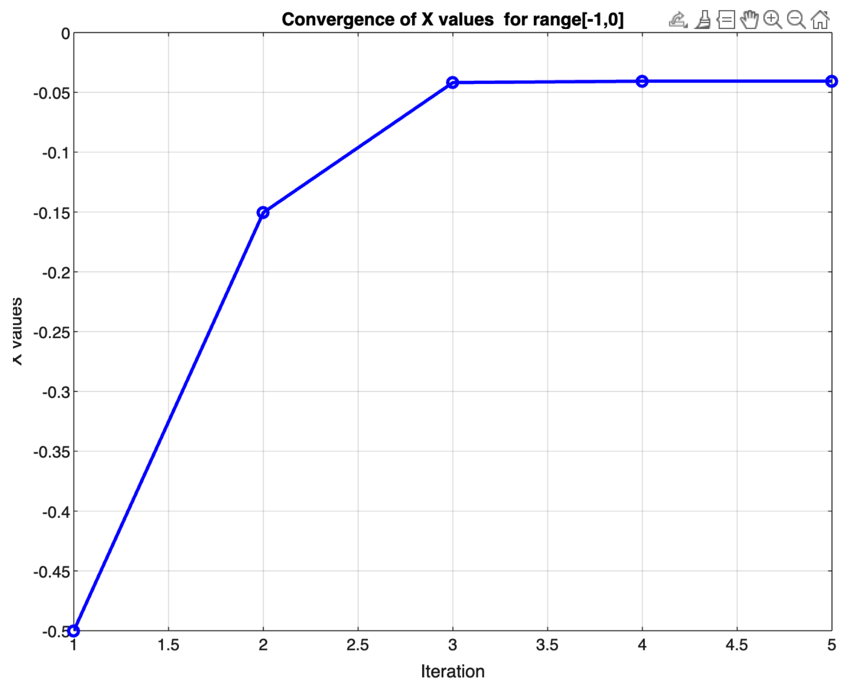


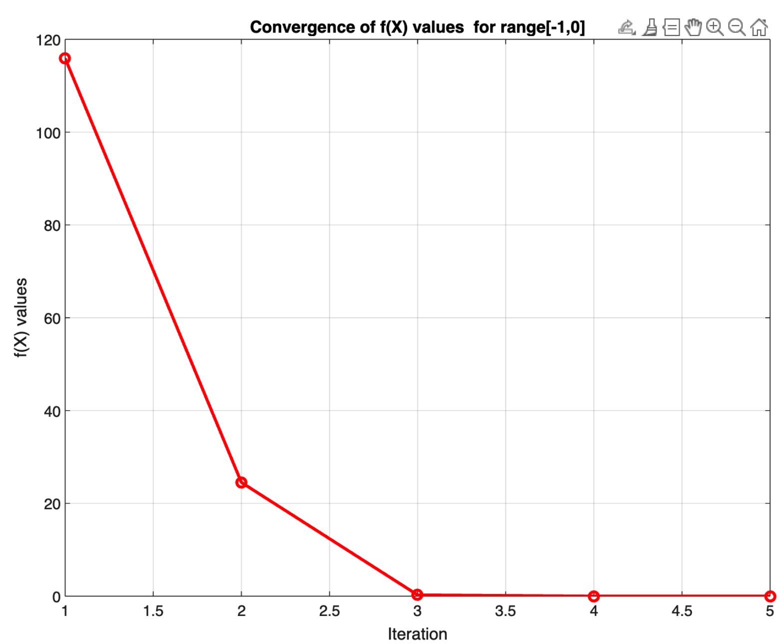


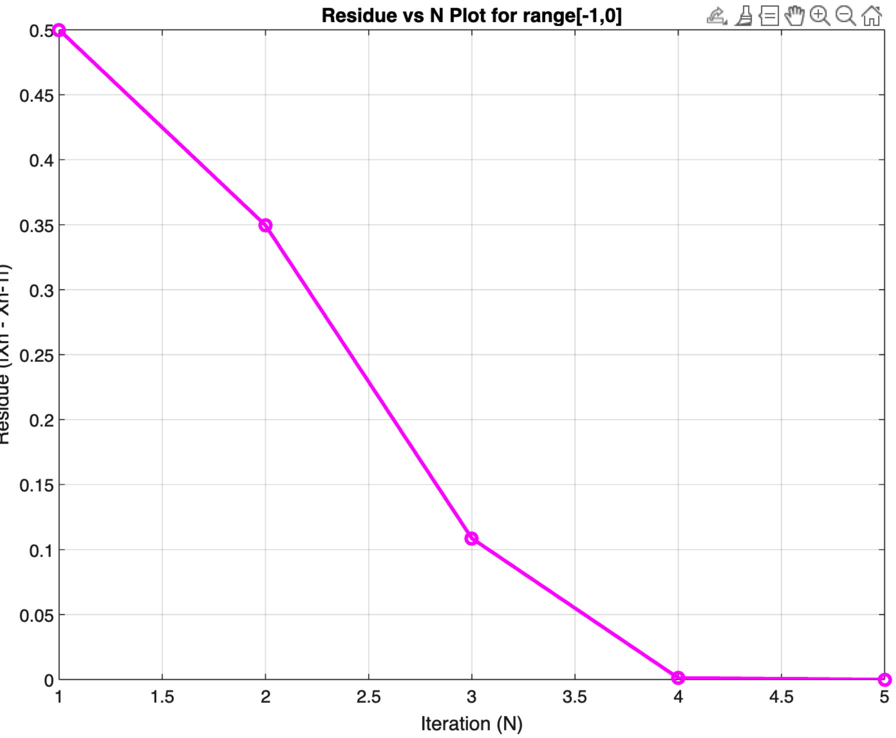
[-1,0] case

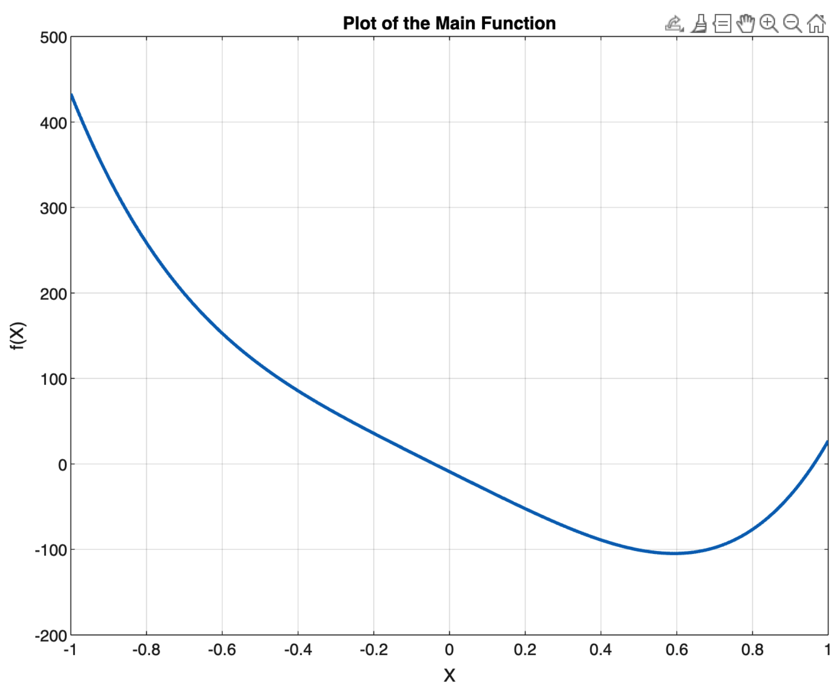
-Used epsilon as 1e-6
- Used Nmax as 10000
- initial approximation = - 0.5

```
Approximate Solution comes out to be -0.04065929
Below Values are up to 8 decimal places for range [-1,0] using Newtons method
Iteration       X               f(x)            Actual Solution         Absolute Error          |Xn - Xn-1|
1               -0.50000000     115.87500000    -0.04065929     0.45934071              0.50000000
2               -0.15045249     24.51027098     -0.04065929     0.10979320              0.34954751
3               -0.04181681     0.25664077      -0.04065929     0.00115753              0.10863567
4               -0.04065934     0.00001223      -0.04065929     0.00000006              0.00115747
5               -0.04065929     0.00000000      -0.04065929     0.00000000              0.00000006
Approximate Solution comes out to be -0.04065929
>>
```







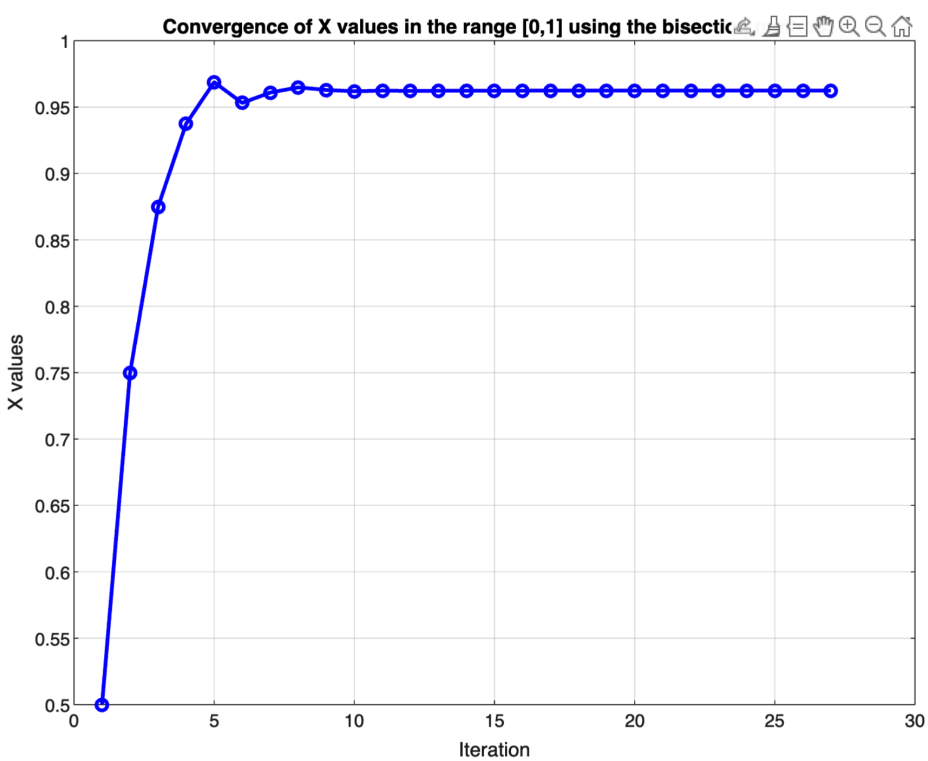


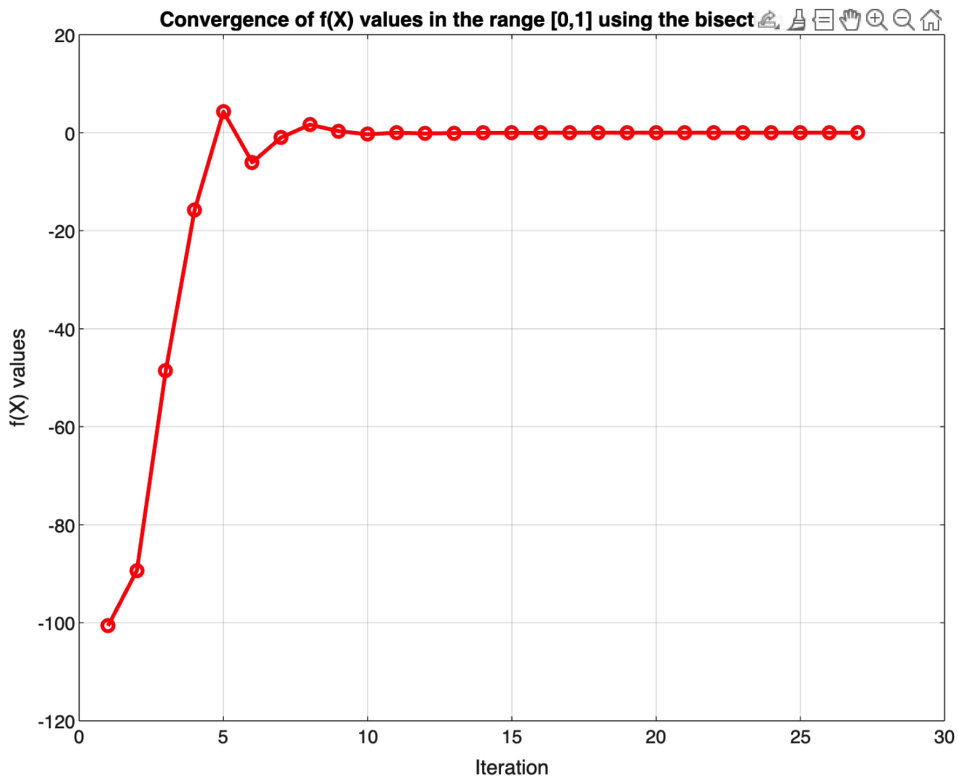
Question-5 B part Bisection Method [0,1] case

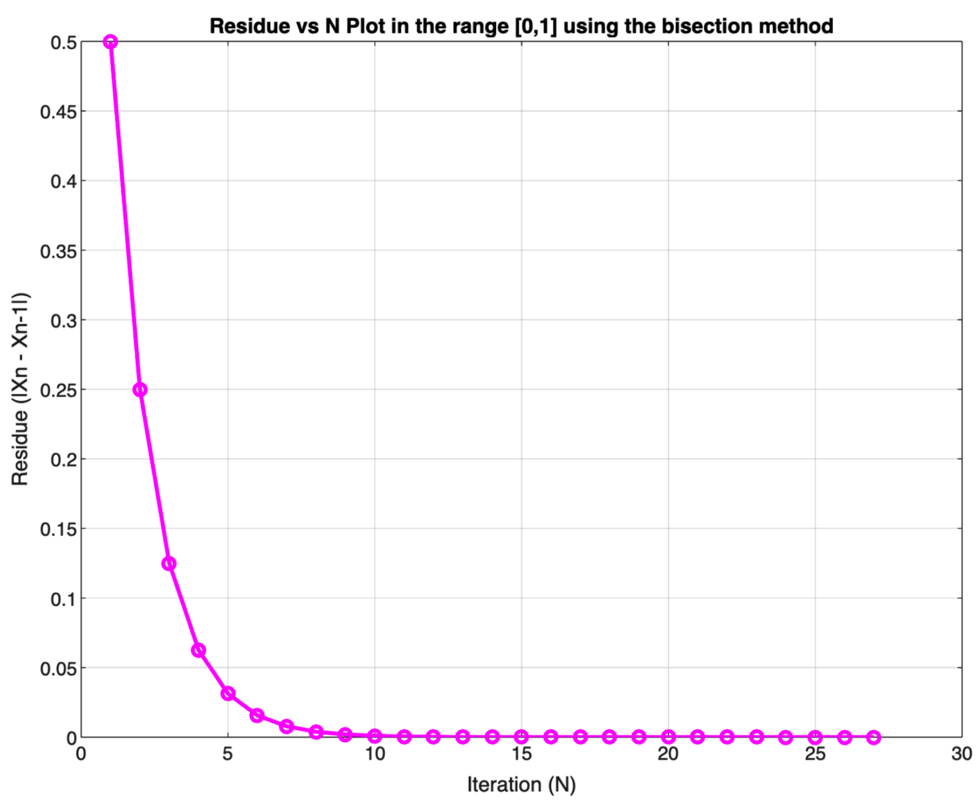
Below Values are up to 8 decimal places in the range [0,1] using the bisection method

Iteration	X	f(x)	Actual Solution	Absolute Error	|Xn − Xn−1|
1	0.50000000	−100.62500000	−0.04065929	0.54065929	0.50000000
2	0.75000000	−89.32031250	−0.04065929	0.79065929	0.25000000
3	0.87500000	−48.60400391	−0.04065929	0.91565929	0.12500000
4	0.93750000	−15.77627563	−0.04065929	0.97815929	0.06250000
5	0.96875000	4.28702354	−0.04065929	1.00940929	0.03125000
6	0.95312500	−6.06547129	−0.04065929	0.99378429	0.01562500
7	0.96093750	−0.97071788	−0.04065929	1.00159679	0.00781250
8	0.96484375	1.63761787	−0.04065929	1.00550304	0.00390625
9	0.96289062	0.32833648	−0.04065929	1.00354991	0.00195312
10	0.96191406	−0.32246655	−0.04065929	1.00257335	0.00097656
11	0.96240234	0.00261569	−0.04065929	1.00306163	0.00048828
12	0.96215820	−0.16000521	−0.04065929	1.00281749	0.00024414
13	0.96228027	−0.07871471	−0.04065929	1.00293956	0.00012207
14	0.96234131	−0.03805450	−0.04065929	1.00300060	0.00006104
15	0.96237183	−0.01772066	−0.04065929	1.00303111	0.00003052
16	0.96238708	−0.00755280	−0.04065929	1.00304637	0.00001526
17	0.96239471	−0.00246863	−0.04065929	1.00305400	0.00000763
18	0.96239853	0.00007351	−0.04065929	1.00305782	0.00000381
19	0.96239662	−0.00119757	−0.04065929	1.00305591	0.00000191
20	0.96239758	−0.00056203	−0.04065929	1.00305686	0.00000095
21	0.96239805	−0.00024426	−0.04065929	1.00305734	0.00000048
22	0.96239829	−0.00008538	−0.04065929	1.00305758	0.00000024
23	0.96239841	−0.00000594	−0.04065929	1.00305770	0.00000012
24	0.96239847	0.00003379	−0.04065929	1.00305776	0.00000006
25	0.96239844	0.00001392	−0.04065929	1.00305773	0.00000003
26	0.96239842	0.00000399	−0.04065929	1.00305771	0.00000001
27	0.96239842	−0.00000097	−0.04065929	1.00305771	0.00000001

Approximate Solution comes out to be 0.96239842




Convergence of f(X) values in the range [0,1] using the bisect
f(X) values
Iteration
20
0
-20
-40
-60
-80
-100
-120
0
5
10
15
20
25
30

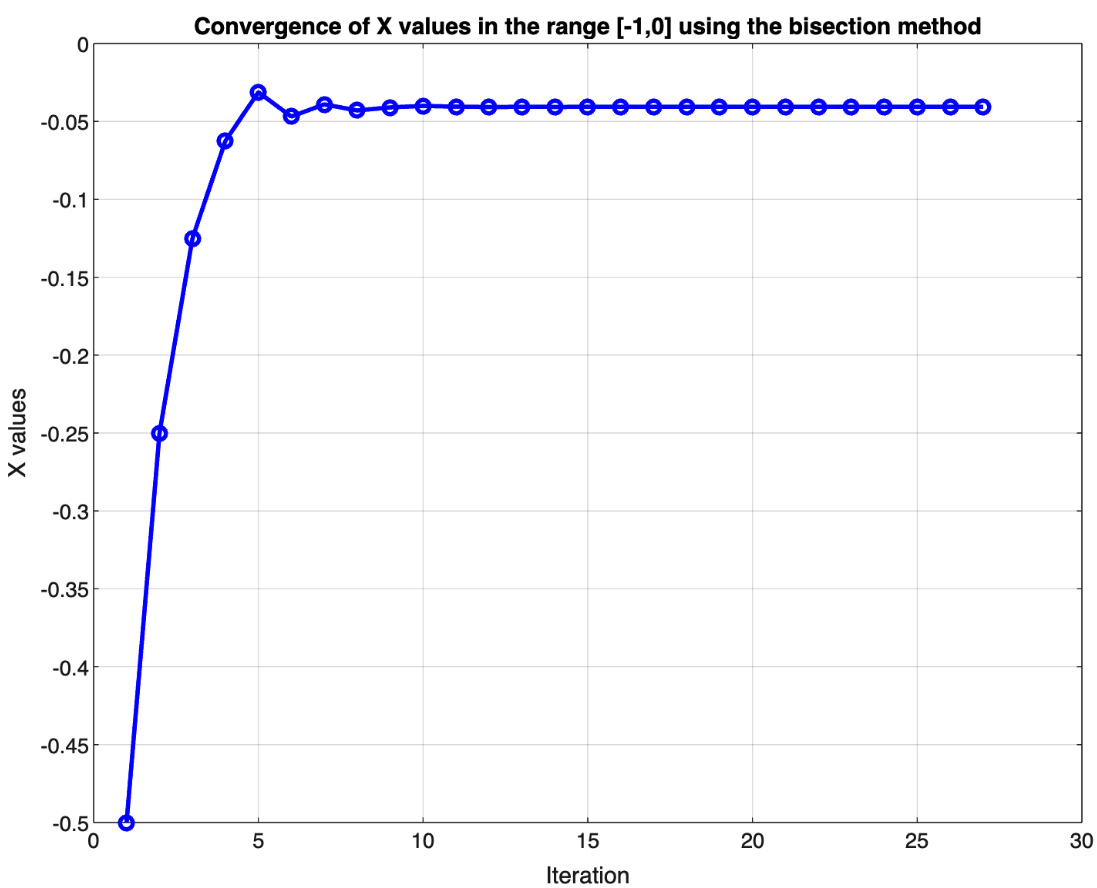

Residue vs N Plot in the range [0,1] using the bisection method
Residue (|Xn - Xn-1|)
Iteration (N)
0.5
0.45
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
0
5
10
15
20
25
30

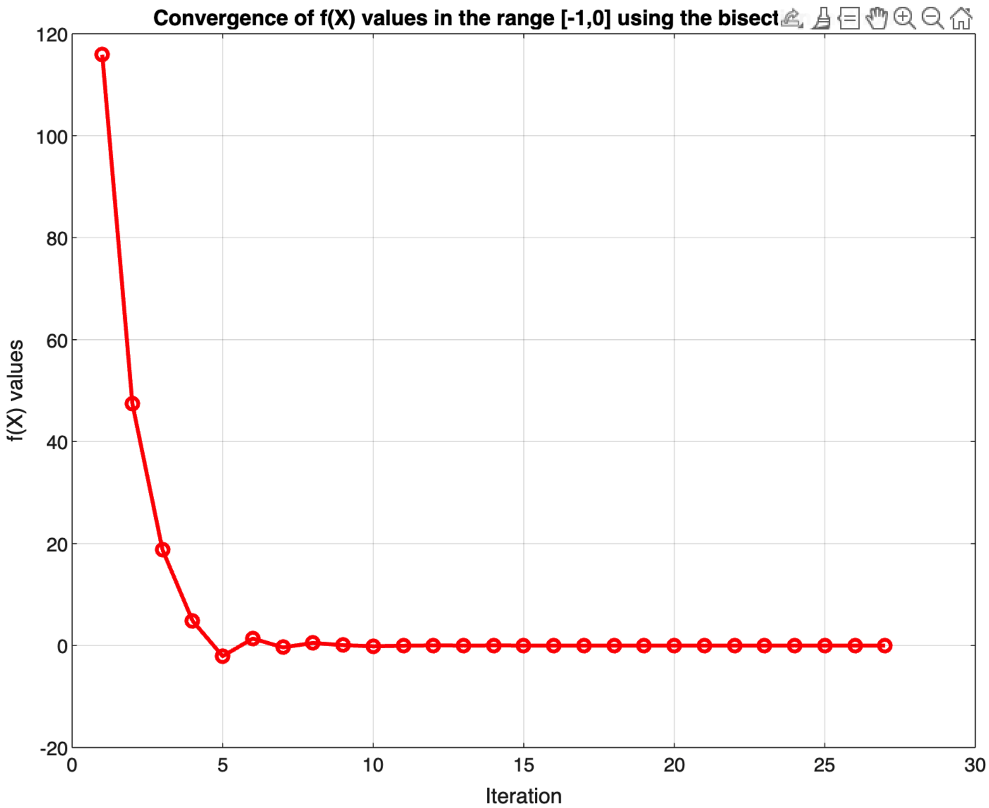
[-1,0] case

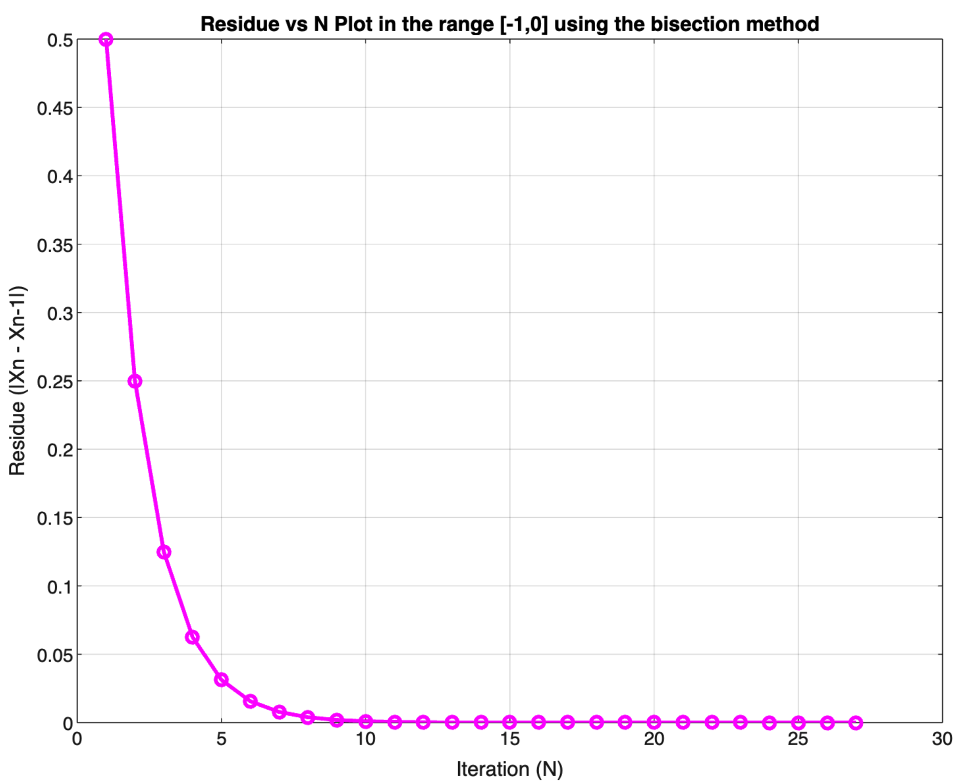
Below Values are up to 8 decimal places in the range [-1,0] using the bisection method

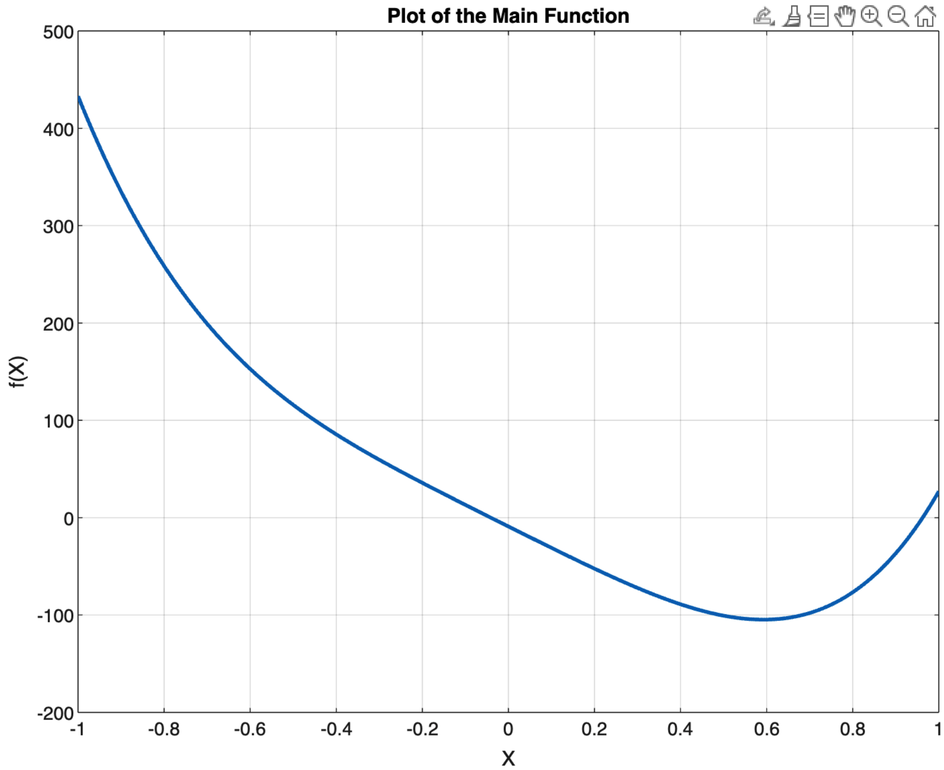
Iteration	X	f(x)	Actual Solution	Absolute Error	|Xn - Xn-1|
1	-0.50000000	115.87500000	-0.04065929	0.45934071	0.50000000
2	-0.25000000	47.42968750	-0.04065929	0.20934071	0.25000000
3	-0.12500000	18.78662109	-0.04065929	0.08434071	0.12500000
4	-0.06250000	4.84677124	-0.04065929	0.02184071	0.06250000
5	-0.03125000	-2.08529091	-0.04065929	0.00940929	0.03125000
6	-0.04687500	1.37840688	-0.04065929	0.00621571	0.01562500
7	-0.03906250	-0.35399196	-0.04065929	0.00159679	0.00781250
8	-0.04296875	0.51206660	-0.04065929	0.00230946	0.00390625
9	-0.04101562	0.07900258	-0.04065929	0.00035634	0.00195312
10	-0.04003906	-0.13750332	-0.04065929	0.00062023	0.00097656
11	-0.04052734	-0.02925254	-0.04065929	0.00013194	0.00048828
12	-0.04077148	0.02487448	-0.04065929	0.00011220	0.00024414
13	-0.04064941	-0.00218916	-0.04065929	0.00000987	0.00012207
14	-0.04071045	0.01134262	-0.04065929	0.00005116	0.00006104
15	-0.04067993	0.00457672	-0.04065929	0.00002064	0.00003052
16	-0.04066467	0.00119378	-0.04065929	0.00000538	0.00001526
17	-0.04065704	-0.00049770	-0.04065929	0.00000224	0.00000763
18	-0.04066086	0.00034804	-0.04065929	0.00000157	0.00000381
19	-0.04065895	-0.00007483	-0.04065929	0.00000034	0.00000191
20	-0.04065990	0.00013661	-0.04065929	0.00000062	0.00000095
21	-0.04065943	0.00003089	-0.04065929	0.00000014	0.00000048
22	-0.04065919	-0.00002197	-0.04065929	0.00000010	0.00000024
23	-0.04065931	0.00000446	-0.04065929	0.00000002	0.00000012
24	-0.04065925	-0.00000875	-0.04065929	0.00000004	0.00000006
25	-0.04065928	-0.00000215	-0.04065929	0.00000001	0.00000003
26	-0.04065929	0.00000116	-0.04065929	0.00000001	0.00000001
27	-0.04065929	-0.00000050	-0.04065929	0.00000000	0.00000001

Approximate Solution comes out to be -0.04065929




Convergence of f(X) values in the range [-1,0] using the bisect
f(X) values
Iteration
120
100
80
60
40
20
0
-20
0
5
10
15
20
25
30


Residue vs N Plot in the range [-1,0] using the bisection method
Residue (|Xn - Xn-1|)
Iteration (N)
0.5
0.45
0.4
0.35
0.3
0.25
0.2
0.15
0.1
0.05
0
0
5
10
15
20
25
30



Observation

1) So for both the cases Newton's method gives us same answer/approximate root . Newton's method doesn't give us a positive root even when the approximation is taken to be 0.5 . This is because Slope of the above curve at 0.5 is negative so the next iterate becomes negative and from that onward iterate converge to negative root

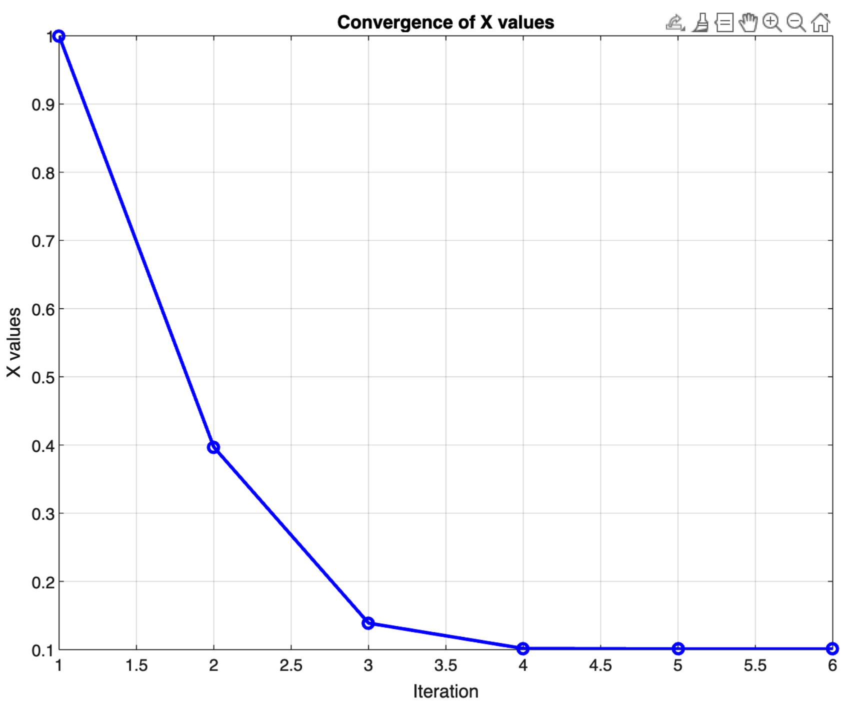
2) But we can see that if we take the approximation to be roughly greater than 0.6 then Newton method will indeed converge to positive root ie 0.9623. This is because nature/slope of the curve changes around the point 0.6.

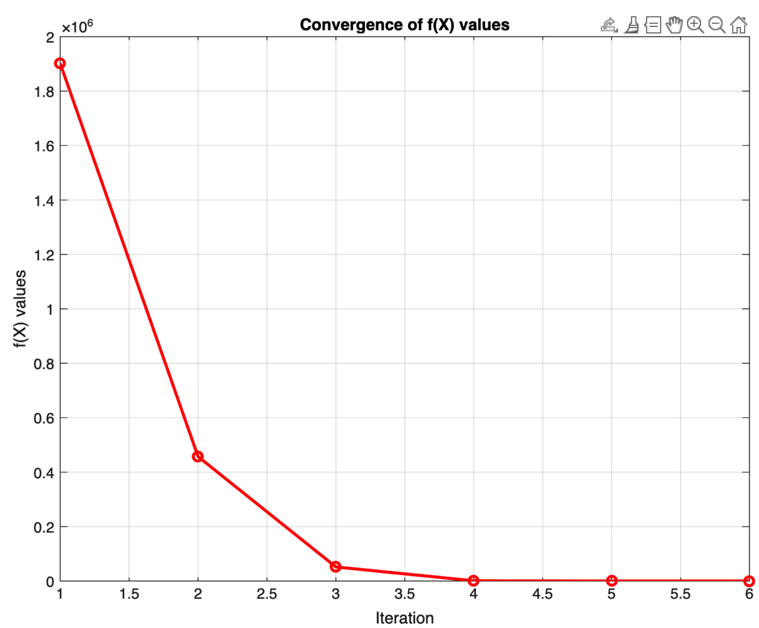
3) Using the Bisection method we get both positive as well as negative roots, this is because the bisection method does not take into account slope of the curve at a particular point, it only checks the sign of the function.

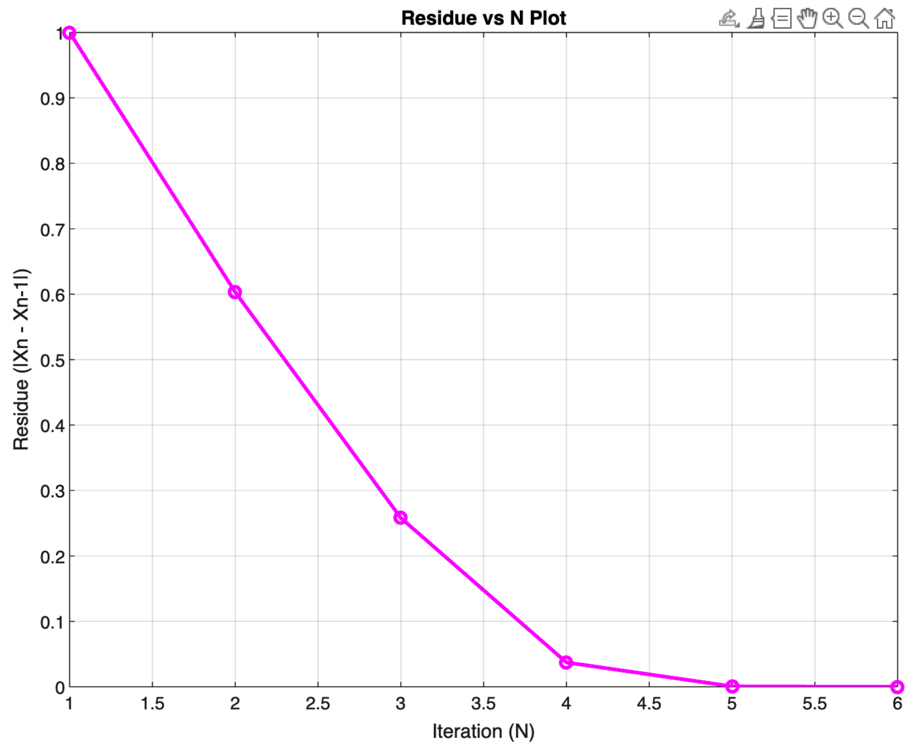
Question-6

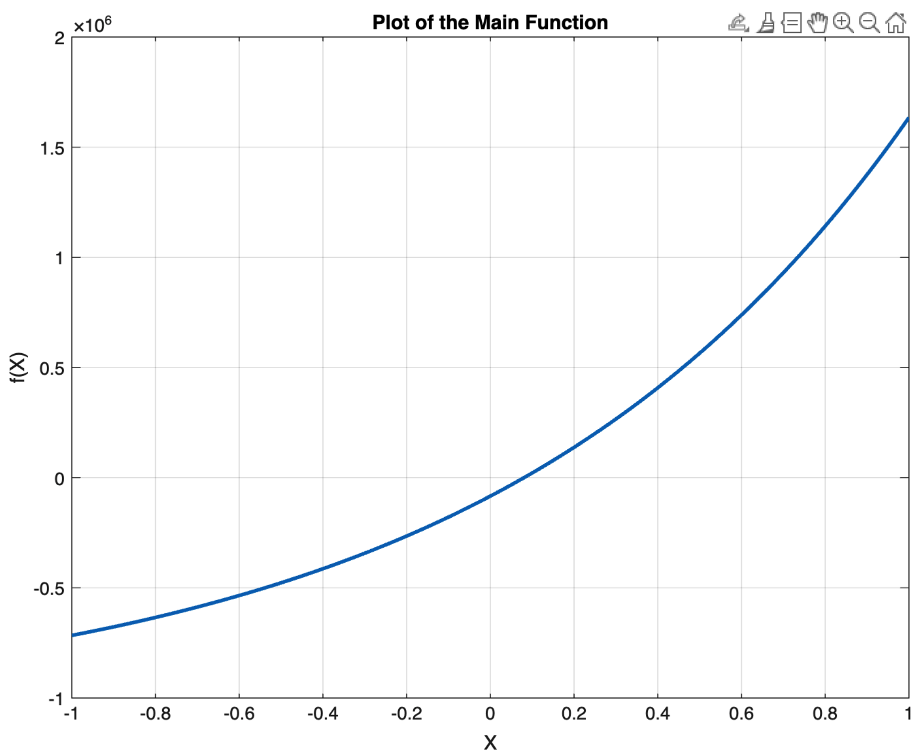
-Used epsilon as 1e-6
- Used Nmax as 10000
- initial approximation = 1

```
Below Values are up to 8 decimal places
Iteration       X               f(x)              Actual Solution         Absolute Error          Residue
1               1.00000000      1901734.42383873        0.10099793      0.89900207              1.00000000
2               0.39690312      457188.88202190 0.10099793      0.29590519              0.60309688
3               0.13886900      51625.63560504  0.10099793      0.03787107              0.25803412
4               0.10166665      895.68948279    0.10099793      0.00066872              0.03720235
5               0.10099814      0.28227736      0.10099793      0.00000021              0.00066851
6               0.10099793      0.00000003      0.10099793      0.00000000              0.00000021
Approximate Solution comes out to be 0.10099793
>>
```





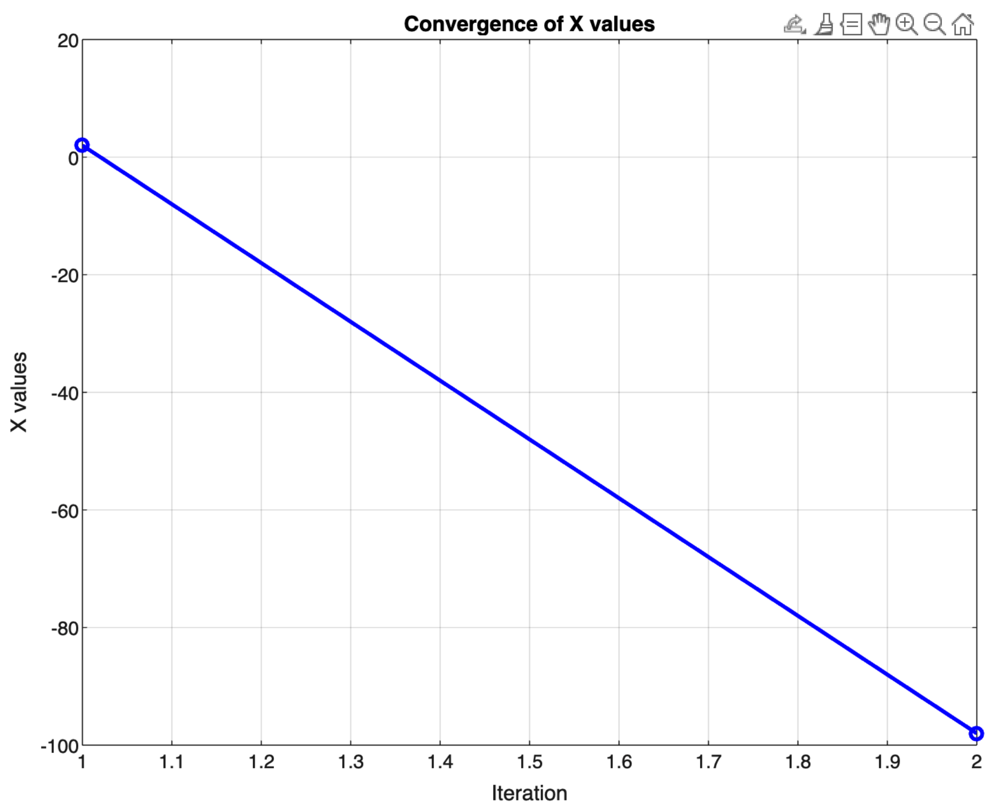

Residue vs N Plot
Residue (|Xn - Xn-1|)
Iteration (N)

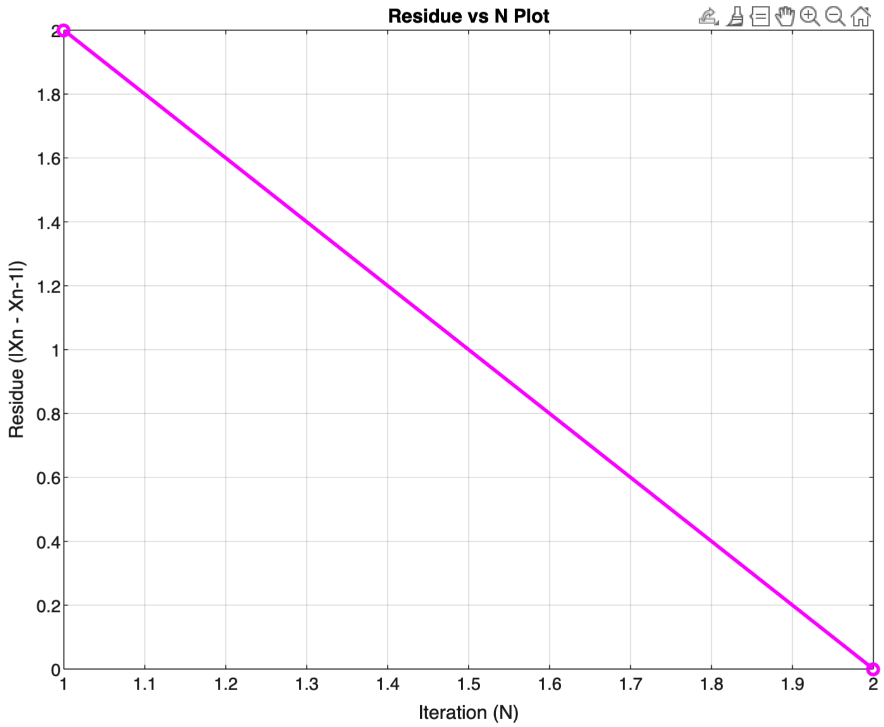

Plot of the Main Function
×10^6
f(X)
X

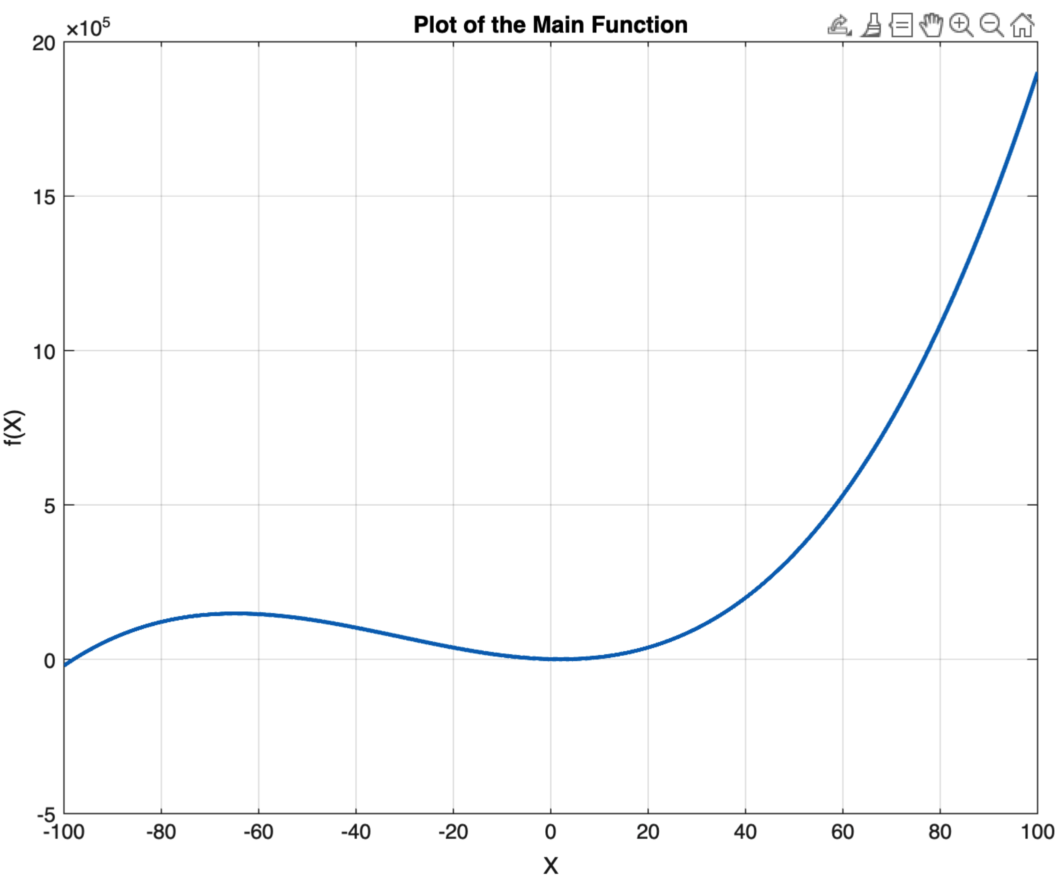
Question-7

-Used epsilon as 1e-6
- Used Nmax as 10000
- initial approximation = 2

```
Below Values are up to 8 decimal places
Iteration       X               f(x)            Actual Solution         Absolute Error          Residue
1               2.00000000      -100.00000000   1.00000000      1.00000000              2.00000000
2               -98.00000000    0.00000000      1.00000000      99.00000000             100.00000000
Approximate Solution comes out to be -98.00000000
>>
```




Residue vs N Plot
Residue (|Xn - Xn-1|)
Iteration (N)
0
0.2
0.4
0.6
0.8
1
1.2
1.4
1.6
1.8
2
1
1.1
1.2
1.3
1.4
1.5
1.6
1.7
1.8
1.9
2


Plot of the Main Function
×10^5
f(X)
X
-5
0
5
10
15
20
-100
-80
-60
-40
-20
0
20
40
60
80
100

Observations

1) So Newton's method gives us a solution for the function at -98. This is because the nature of function changes around 2.005 from decreasing to increasing, hence the next iterate goes in negative direction thus converging to negative root at -98.

2) If the initial approximation is taken as 2.007 then Newton's method converges to another root i.e. 3. This is because at point 2.007 , Function’s sign is negative and slope is positive ,thus the next iterate becomes larger than the previous iterate and thus subsequent iterates converges at 3.

```
Below Values are up to 8 decimal places
Iteration       X               f(x)            Actual Solution         Absolute Error          Residue
1               2.00700000      -100.00209966   1.00000000      1.00700000              2.00700000
2               251.92040597    21855751.88088882       1.00000000      250.92040597            249.91340597
3               159.84334853    6423786.10999456        1.00000000      158.84334853            92.07705744
4               99.41901101     1873400.54009099        1.00000000      98.41901101             60.42433751
5               60.35255175     539035.30001371 1.00000000      59.35255175             39.06645927
6               35.72171507     151928.47041233 1.00000000      34.72171507             24.63083668
7               20.76047581     41679.63653478  1.00000000      19.76047581             14.96123926
8               12.08979343     11097.48399478  1.00000000      11.08979343             8.67068238
9               7.31127765      2865.48514013   1.00000000      6.31127765              4.77851578
10              4.81060237      709.34028074    1.00000000      3.81060237              2.50067528
11              3.59767946      157.73849110    1.00000000      2.59767946              1.21292291
12              3.11410628      24.39204023     1.00000000      2.11410628              0.48357318
13              3.00595915      1.20740647      1.00000000      2.00595915              0.10814713
14              3.00001800      0.00363604      1.00000000      2.00001800              0.00594115
15              3.00000000      0.00000003      1.00000000      2.00000000              0.00001800
Approximate Solution comes out to be 3.00000000
```

>> test
Below Values are up to 8 decimal places

Iteration	X	f(x)	Actual Solution	Absolute Error	Residue
1	2.00700000	-100.00209966	1.00000000	1.00700000	2.00700000
2	251.92040597	21855751.88088882	1.00000000	250.92040597	249.91340597
3	159.84334853	6423786.10999456	1.00000000	158.84334853	92.07705744
4	99.41901101	1873400.54009099	1.00000000	98.41901101	60.42433751
5	60.35255175	539035.30001371	1.00000000	59.35255175	39.06645927
6	35.72171507	151928.47041233	1.00000000	34.72171507	24.63083668
7	20.76047581	41679.63653478	1.00000000	19.76047581	14.96123926
8	12.08979343	11097.48399478	1.00000000	11.08979343	8.67068238
9	7.31127765	2865.48514013	1.00000000	6.31127765	4.77851578
10	4.81060237	709.34028074	1.00000000	3.81060237	2.50067528
11	3.59767946	157.73849110	1.00000000	2.59767946	1.21292291
12	3.11410628	24.39204023	1.00000000	2.11410628	0.48357318
13	3.00595915	1.20740647	1.00000000	2.00595915	0.10814713
14	3.00001800	0.00363604	1.00000000	2.00001800	0.00594115
15	3.00000000	0.00000003	1.00000000	2.00000000	0.00001800

Approximate Solution comes out to be 3.00000000
>>