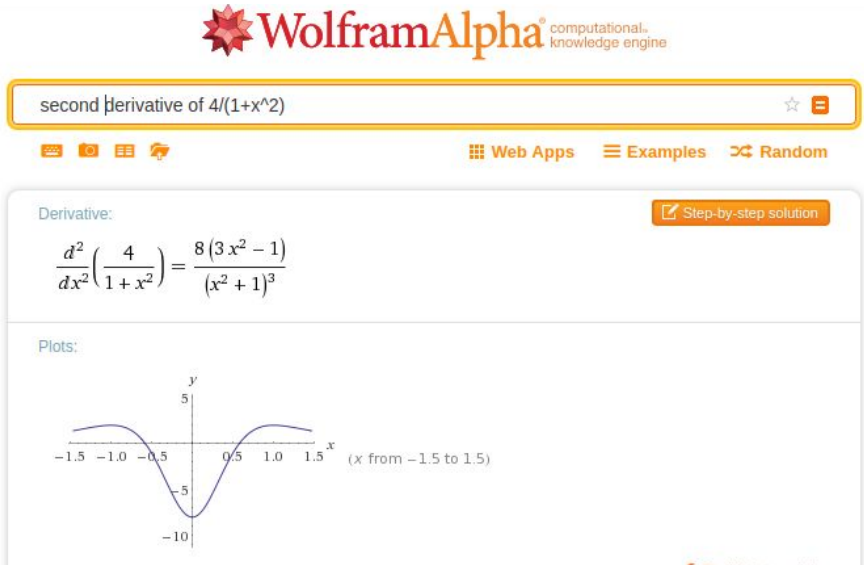
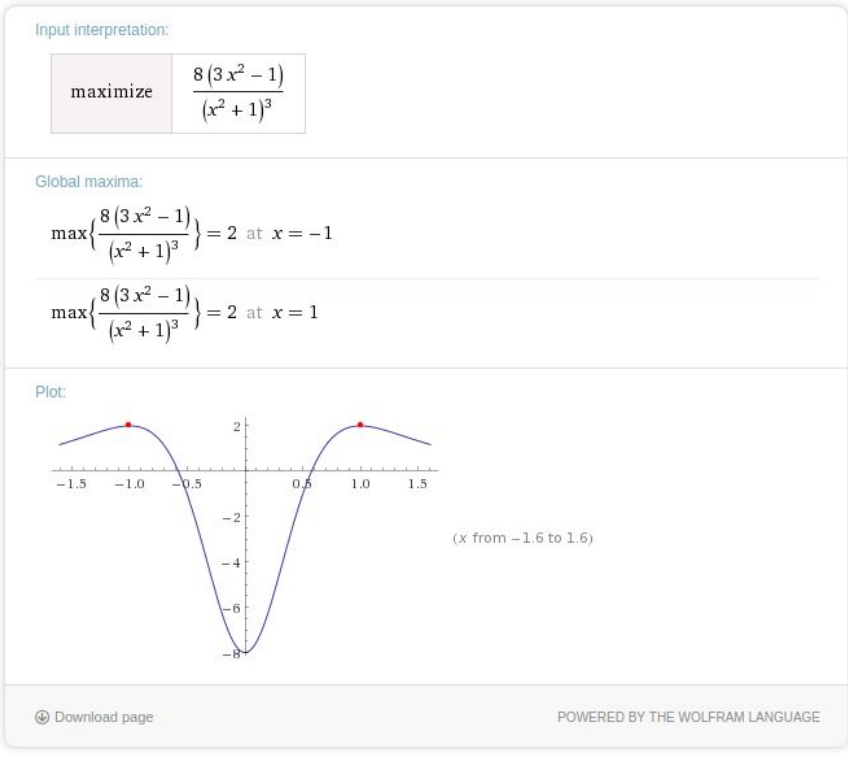
Exercise 1

1) Find a upper bound

Second derivative of f(x) is



The maximum value of $\frac{8\left(3x^2-1\right)}{\left(x^2+1\right)^3}$ is 2 at x=-+1 and the minimum is -8



The highest value is 8 because we take module from function

The error made is then ≤ 2/3n^2

2) Please see attached file Exercise1_2.c

It can be compiled using command

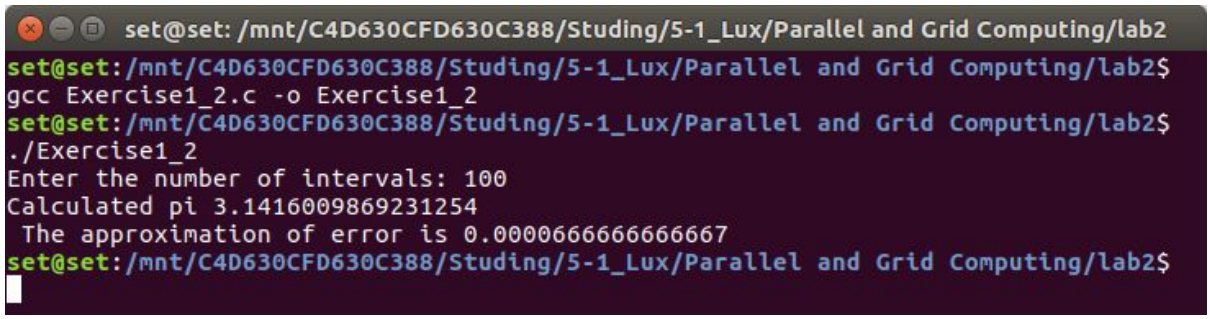
gcc Exercise1_2.c -o Exercise1_2

Run command

./Exercise1_2

n

where n is the number of intervals.



3)

Partitioning - process will calculate it own bunch of intervals based on its id of process.

Communications – process 0 will send number of intervals to other processes. Then, calculated values will be summed and final result will be obtained by process 0.

Mapping – algorithm is highly parallelized that is why it not necessary to worry about issues during communication.

Agglomeration – uses at the end of calculation when need to summarize all results from processes. Process with id 0 hold the summarize result.

Please see attached file Exercise1_3.c

It can be compiled using command

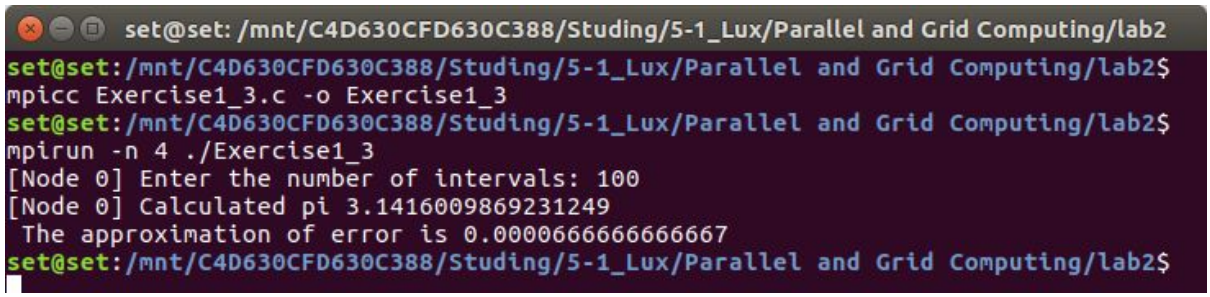
mpicc Exercise1_3.c -o Exercise1_3

Run command

mpirun -n kolProcess ./Exercise1_3

n

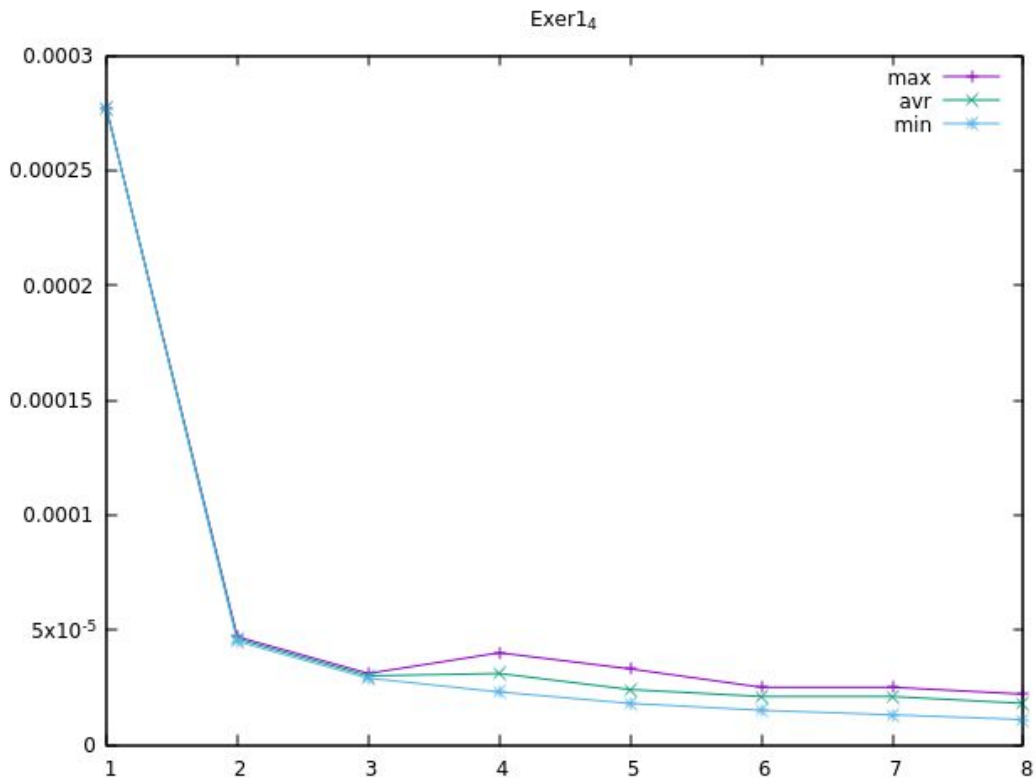
where n is the number of intervals and kolProcess number of processes



4) Please see attached file Exercise1_4.c
It can be compiled using next command
mpicc Exercise1_4.c -o Exercise1_4

Run command
mpirun -n kolProcess ./Exercise1_4
n
where n is the number of intervals and kolProcess number of processes

```
set@set: /mnt/C4D630CFD630C388/Studing/5-1_Lux/Parallel and Grid Computing/lab2
set@set:/mnt/C4D630CFD630C388/Studing/5-1_Lux/Parallel and Grid Computing/lab2$
mpicc Exercise1_4.c -o Exercise1_4
set@set:/mnt/C4D630CFD630C388/Studing/5-1_Lux/Parallel and Grid Computing/lab2$
mpirun -n 4 ./Exercise1_4
[Node 0] Enter the number of intervals: 100
[Node 0] done!
 Found max process time 0.000001
 Found avr process time 0.000000
 Found min process time 0.000000
[Node 0] Calculated pi 3.1416009869231249
 The approximation of error is 0.0000666666666667
set@set:/mnt/C4D630CFD630C388/Studing/5-1_Lux/Parallel and Grid Computing/lab2$
mpirun -n 4 ./Exercise1_4
[Node 0] Enter the number of intervals: 1000
[Node 0] done!
 Found max process time 0.000009
 Found avr process time 0.000004
 Found min process time 0.000002
[Node 0] Calculated pi 3.1415927369231262
 The approximation of error is 0.0000006666666667
set@set:/mnt/C4D630CFD630C388/Studing/5-1_Lux/Parallel and Grid Computing/lab2$
```

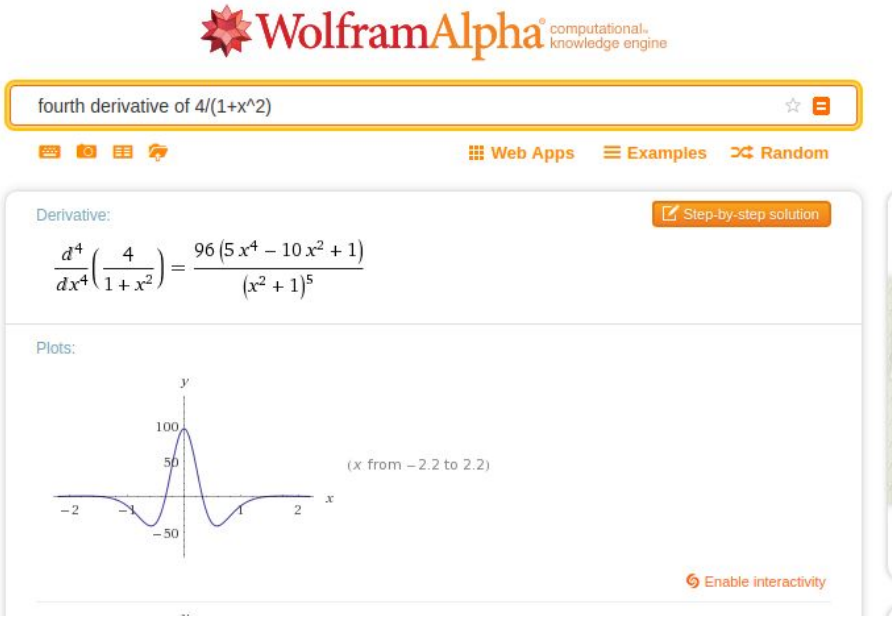


Exercise 2

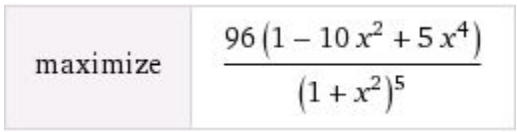
The error made is then $|E_s| \leq \frac{K(b-a)^5}{180n^4}$ $|f^{(4)}(x)| \leq K$

Find a upper bound

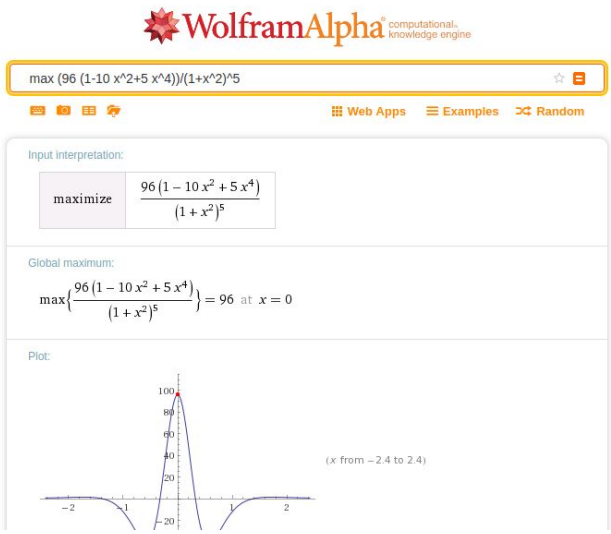
Fourth derivative of f(x) is



The maximum value of



is 96 at x=0



The highest value is 96 because we take module from function

The error made is then ≤ 96/(180*n^4)

1) Please see attached file Exercise2_1.c

It can be compiled using command

gcc Exercise2_1.c -o Exercise2_1

Run command

./Exercise2_1
n

where n is the number of intervals.

```
set@set: /mnt/C4D630CFD630C388/Studing/5-1_Lux/Parallel and Grid Computing/lab2
set@set:/mnt/C4D630CFD630C388/Studing/5-1_Lux/Parallel and Grid Computing/lab2$
gcc Exercise2_1.c -o Exercise2_1
set@set:/mnt/C4D630CFD630C388/Studing/5-1_Lux/Parallel and Grid Computing/lab2$
./Exercise2_1
Enter the number of intervals: 10
Calculated pi 3.1415926529697860
 The approximation of error is 0.0000533333333333
set@set:/mnt/C4D630CFD630C388/Studing/5-1_Lux/Parallel and Grid Computing/lab2$
```

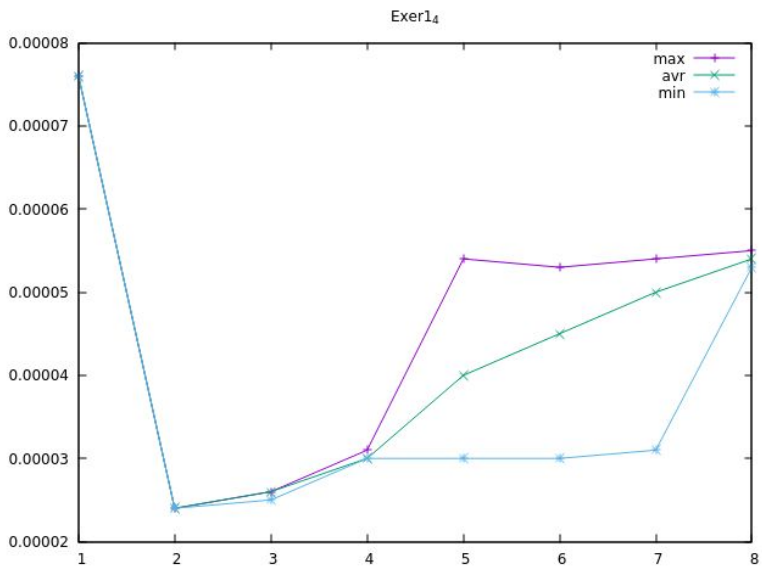
2) Approach for parallel programing of this algorithm is the same as for previous algorithm
Please see attached file Exercise2_2.c

It can be compiled using command
mpicc Exercise2_2.c -o Exercise2_2

Run command
mpirun -n kolProcess ./Exercise2_2
n

where n is the number of intervals and kolProcess number of processes

```
set@set: /mnt/C4D630CFD630C388/Studing/5-1_Lux/Parallel and Grid Computing/lab2
set@set:/mnt/C4D630CFD630C388/Studing/5-1_Lux/Parallel and Grid Computing/lab2$
mpicc Exercise2_2,3.c -o Exercise2_2,3
set@set:/mnt/C4D630CFD630C388/Studing/5-1_Lux/Parallel and Grid Computing/lab2$
mpirun -n 4 Exercise2_2,3
[Node 0] Enter the number of intervals: 10
Calculated pi 3.1415926535896417
 The approximation of error is 0.0000533333333333
[Node 0] done!
 Found max process time 0.000001
 Found avr process time 0.000001
 Found min process time 0.000001
set@set:/mnt/C4D630CFD630C388/Studing/5-1_Lux/Parallel and Grid Computing/lab2$
```

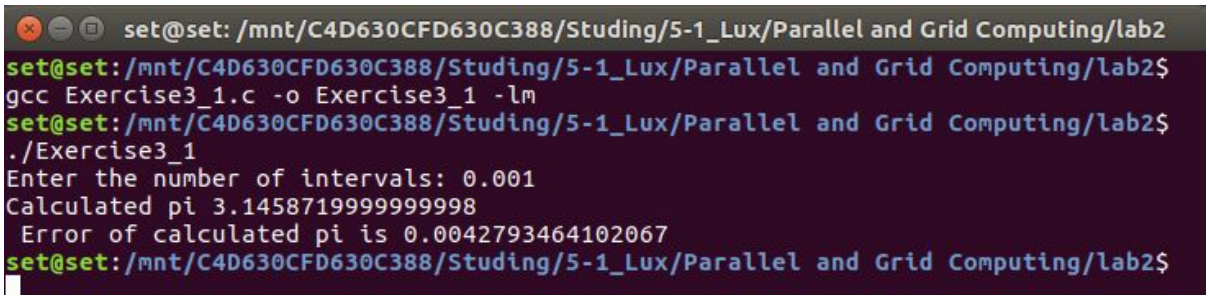


Exercise 3

1) Please see attached file Exercise3_1.c

It can be compiled using command
gcc Exercise3_1.c -o Exercise3_1 -lm

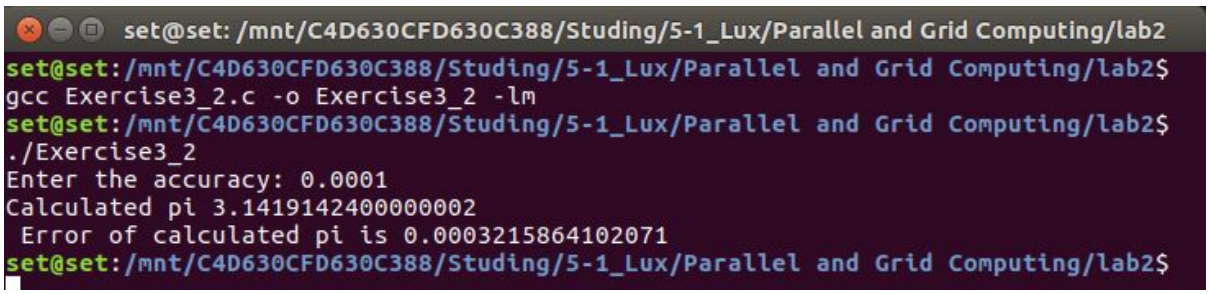
Run command
./Exercise3_1
e
where e is the accuracy.



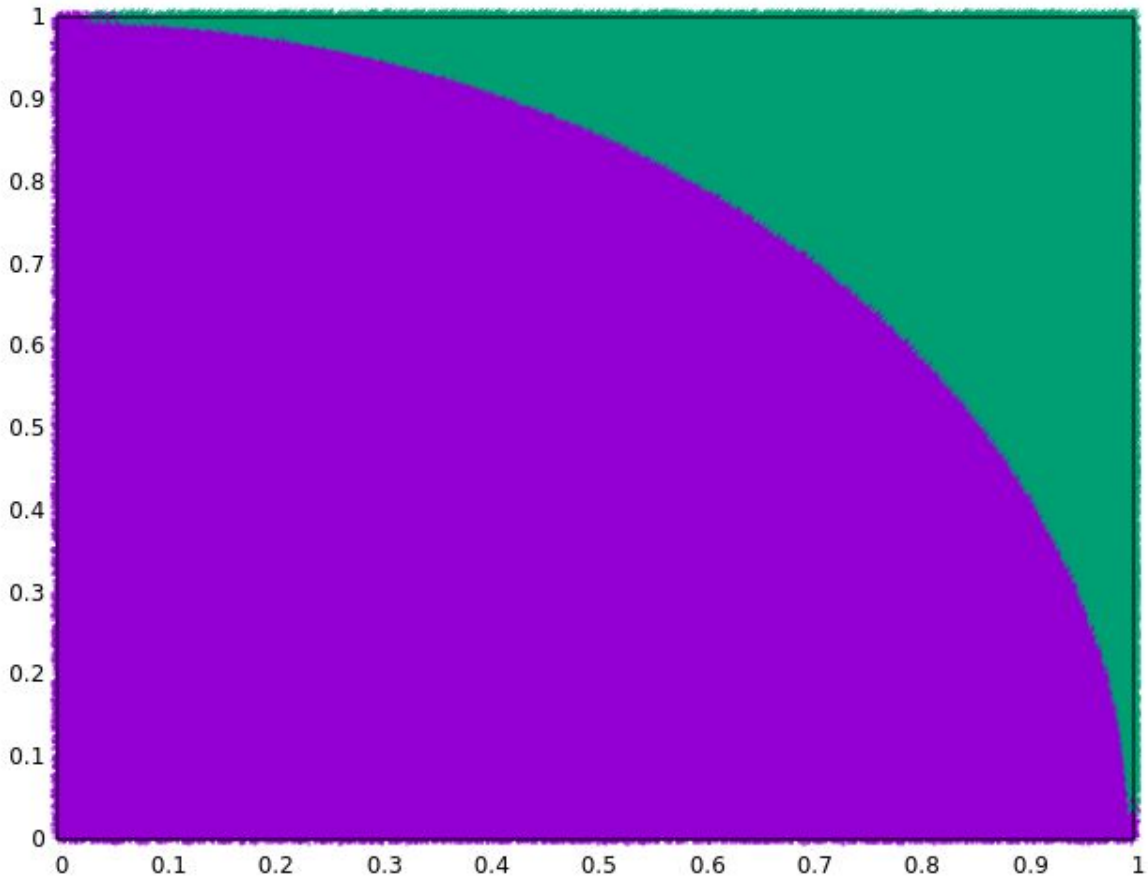
2) Please see attached file Exercise3_2.c

It can be compiled using command
gcc Exercise3_2.c -o Exercise3_2 -lm

Run command
./Exercise3_2
e
where e is the accuracy.



Plot



3,4) Please see attached file Exercise3_3,4.c
It can be compiled using command
gcc Exercise3_3,4.c -o Exercise3_3,4 -lm

Run command
./Exercise3_3,4
e
where e is the accuracy.

```
set@set: /mnt/C4D630CFD630C388/Studing/5-1_Lux/Parallel and Grid Computing/lab2
set@set:/mnt/C4D630CFD630C388/Studing/5-1_Lux/Parallel and Grid Computing/lab2$
mpicc Exercise3_3,4.c -o Exercise3_3,4 -lm
set@set:/mnt/C4D630CFD630C388/Studing/5-1_Lux/Parallel and Grid Computing/lab2$
mpirun -n 4 Exercise3_3,4
[Node 0] Enter the accuracy: 0.001
Calculated PI = 3.14098203592814373, Error is 0.00061061766164938
set@set:/mnt/C4D630CFD630C388/Studing/5-1_Lux/Parallel and Grid Computing/lab2$
```

5) Please see attached file Exercise3_5.c
It can be compiled using command
gcc Exercise3_5.c -o Exercise3_5 -lm

Run command
./Exercise3_5
e
where e is the accuracy.

```
set@set: /mnt/C4D630CFD630C388/Studing/5-1_Lux/Parallel and Grid Computing/lab2
set@set:/mnt/C4D630CFD630C388/Studing/5-1_Lux/Parallel and Grid Computing/lab2$
mpicc Exercise3_5.c -o Exercise3_5 -lm
set@set:/mnt/C4D630CFD630C388/Studing/5-1_Lux/Parallel and Grid Computing/lab2$
mpirun -n 4 Exercise3_5
[Node 0] Enter the accuracy: 0.001
[Node 0] Calculated PI = 3.14098203592814373, Error is 0.00061061766164938
set@set:/mnt/C4D630CFD630C388/Studing/5-1_Lux/Parallel and Grid Computing/lab2$
```

Plot