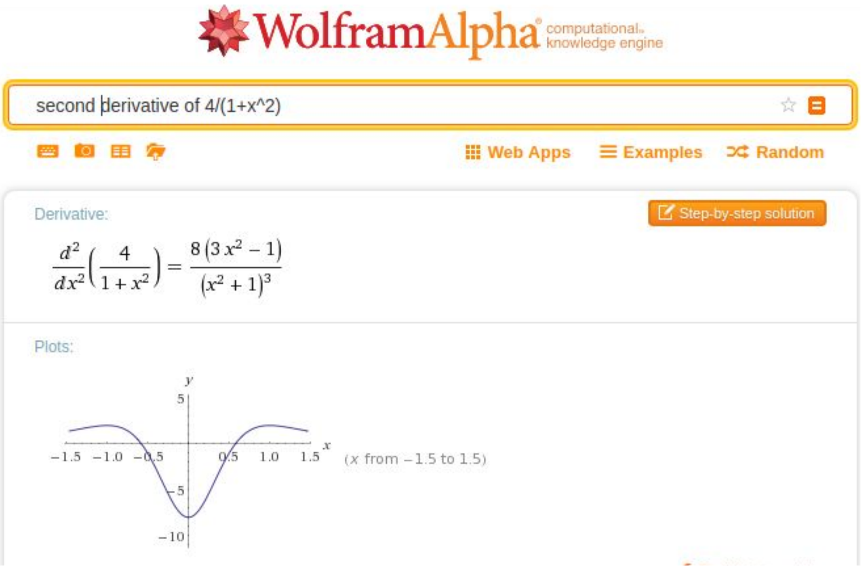
Exercise 1

1) Find a upper bound

Second derivative of f(x) is



WolframAlpha computational knowledge engine

second derivative of 4/(1+x^2)

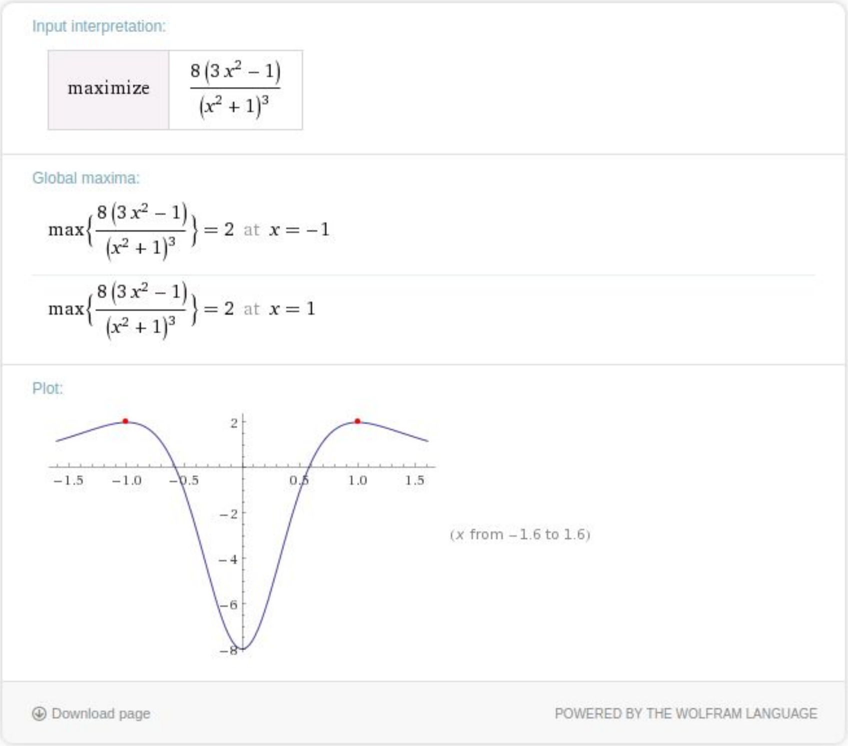
Derivative:

$$\frac{d^2}{dx^2}\left(\frac{4}{1+x^2}\right) = \frac{8\,(3\,x^2-1)}{(x^2+1)^3}$$

Plots:

(x from −1.5 to 1.5)

The maximum value of $\frac{8\,(3\,x^2-1)}{(x^2+1)^3}$ is 2 at x=-+1



Input interpretation:

maximize	$\frac{8\,(3\,x^2-1)}{(x^2+1)^3}$

Global maxima:

$$\max\left\{\frac{8\,(3\,x^2-1)}{(x^2+1)^3}\right\} = 2 \text{ at } x = -1$$

$$\max\left\{\frac{8\,(3\,x^2-1)}{(x^2+1)^3}\right\} = 2 \text{ at } x = 1$$

Plot:

(x from −1.6 to 1.6)

The error made is then ≤ 1/6n^2

2) Please see attached file Exercise1_2.c

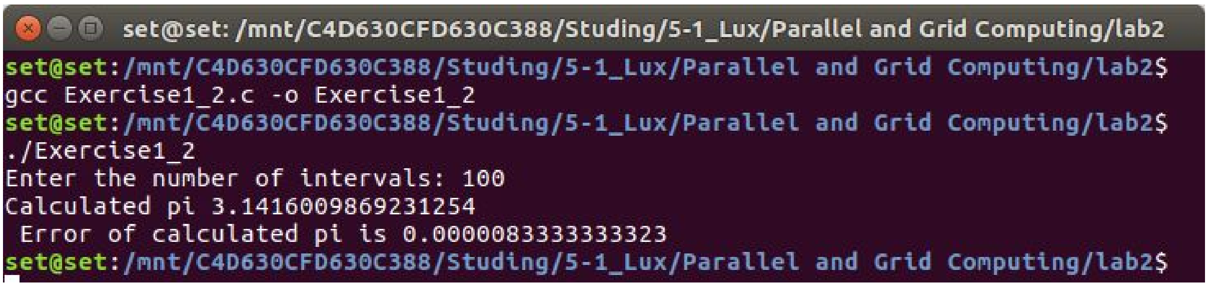
It can be compiled using command

```
gcc Exercise1_2.c -o Exercise1_2
```

Run command

```
./Exercise1_2
n
```

where n is the number of intervals.



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 Exercise1_2.c -o Exercise1_2
set@set:/mnt/C4D630CFD630C388/Studing/5-1_Lux/Parallel and Grid Computing/lab2$
./Exercise1_2
Enter the number of intervals: 100
Calculated pi 3.1416009869231254
 Error of calculated pi is 0.0000083333333323
set@set:/mnt/C4D630CFD630C388/Studing/5-1_Lux/Parallel and Grid Computing/lab2$
```

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

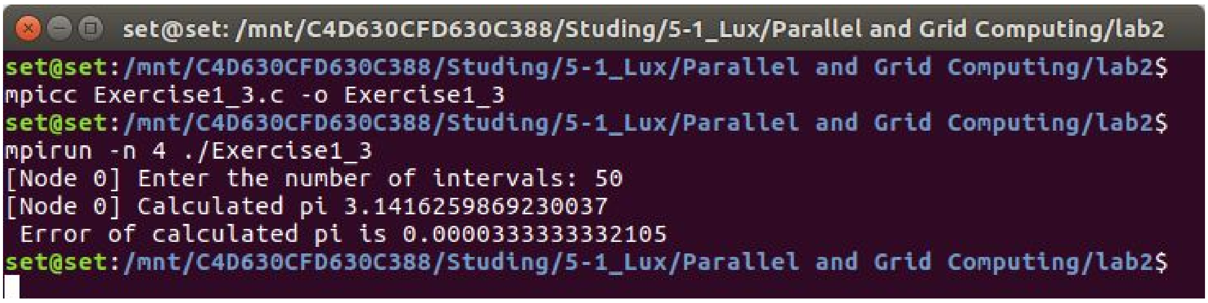
It can be compiled using command

```
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



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_3.c -o Exercise1_3
set@set:/mnt/C4D630CFD630C388/Studing/5-1_Lux/Parallel and Grid Computing/lab2$
mpirun -n 4 ./Exercise1_3
[Node 0] Enter the number of intervals: 50
[Node 0] Calculated pi 3.1416259869230037
 Error of calculated pi is 0.0000333333332105
set@set:/mnt/C4D630CFD630C388/Studing/5-1_Lux/Parallel and Grid Computing/lab2$
```

4) Please see attached file Exercise1_4.c

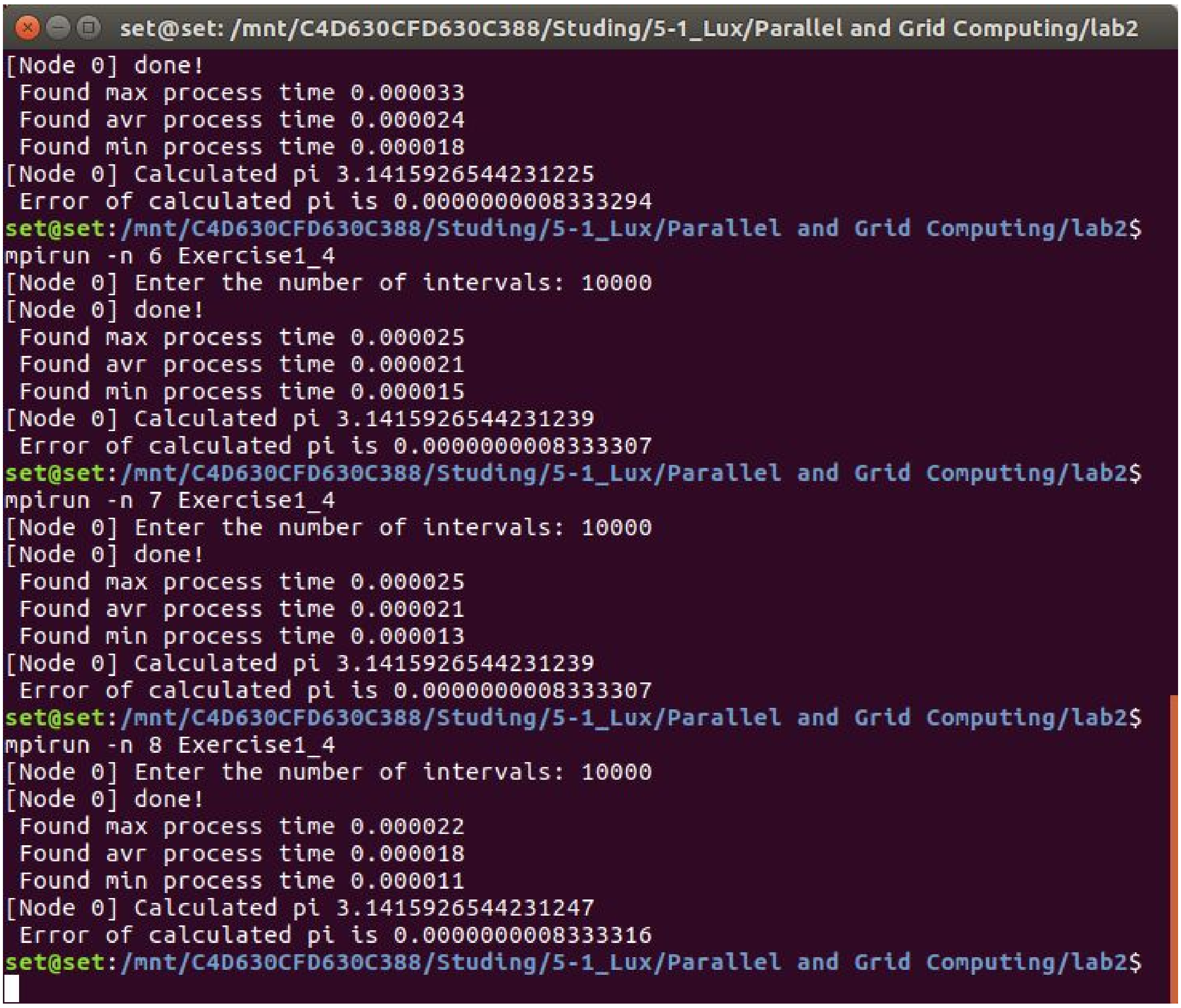
It can be compiled using command

```
mpicc Exercise1_4.c -o Exercise1_4
```

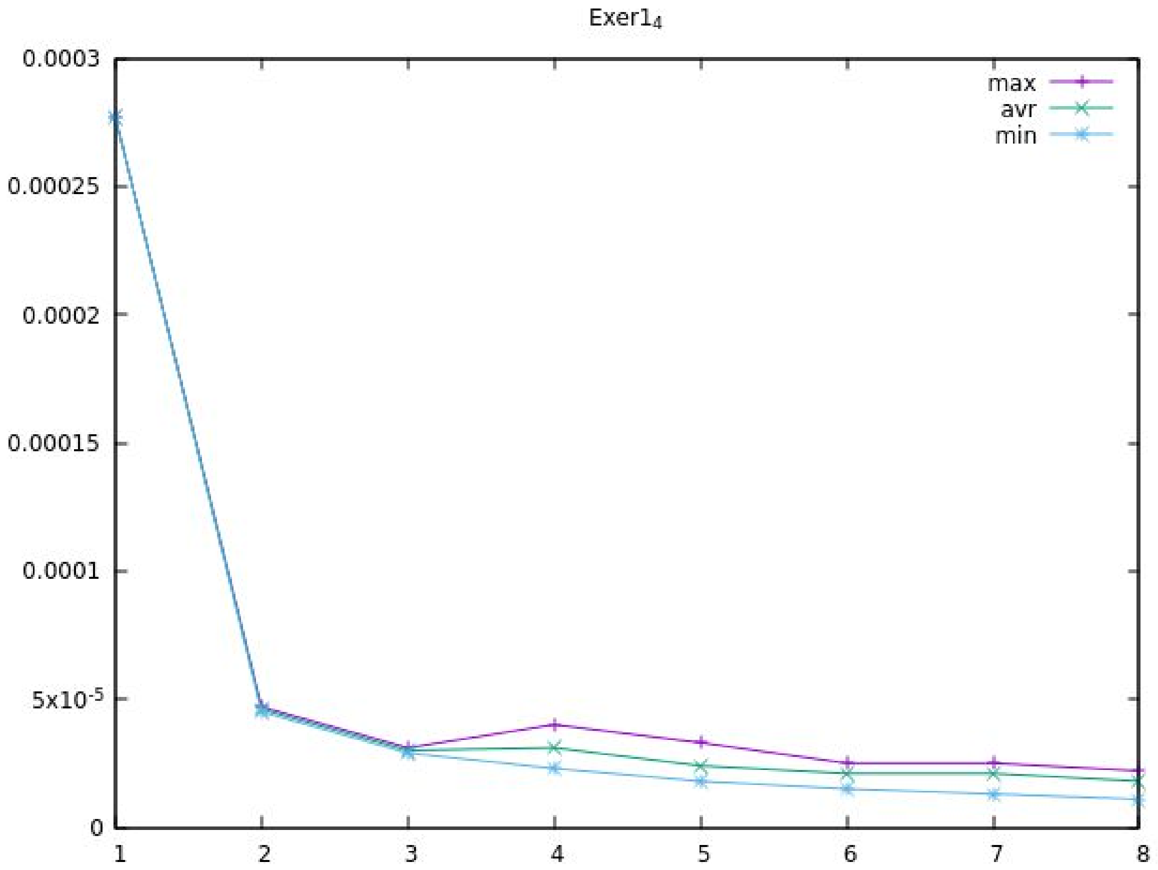
Run command

```
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

```
[Node 0] done!
 Found max process time 0.000033
 Found avr process time 0.000024
 Found min process time 0.000018
[Node 0] Calculated pi 3.1415926544231225
 Error of calculated pi is 0.0000000008333294
set@set:/mnt/C4D630CFD630C388/Studing/5-1_Lux/Parallel and Grid Computing/lab2$
mpirun -n 6 Exercise1_4
[Node 0] Enter the number of intervals: 10000
[Node 0] done!
 Found max process time 0.000025
 Found avr process time 0.000021
 Found min process time 0.000015
[Node 0] Calculated pi 3.1415926544231239
 Error of calculated pi is 0.0000000008333307
set@set:/mnt/C4D630CFD630C388/Studing/5-1_Lux/Parallel and Grid Computing/lab2$
mpirun -n 7 Exercise1_4
[Node 0] Enter the number of intervals: 10000
[Node 0] done!
 Found max process time 0.000025
 Found avr process time 0.000021
 Found min process time 0.000013
[Node 0] Calculated pi 3.1415926544231239
 Error of calculated pi is 0.0000000008333307
set@set:/mnt/C4D630CFD630C388/Studing/5-1_Lux/Parallel and Grid Computing/lab2$
mpirun -n 8 Exercise1_4
[Node 0] Enter the number of intervals: 10000
[Node 0] done!
 Found max process time 0.000022
 Found avr process time 0.000018
 Found min process time 0.000011
[Node 0] Calculated pi 3.1415926544231247
 Error of calculated pi is 0.0000000008333316
set@set:/mnt/C4D630CFD630C388/Studing/5-1_Lux/Parallel and Grid Computing/lab2$
```



Exercise 2

1) Please see attached file Exercise2_1.c

It can be compiled using command

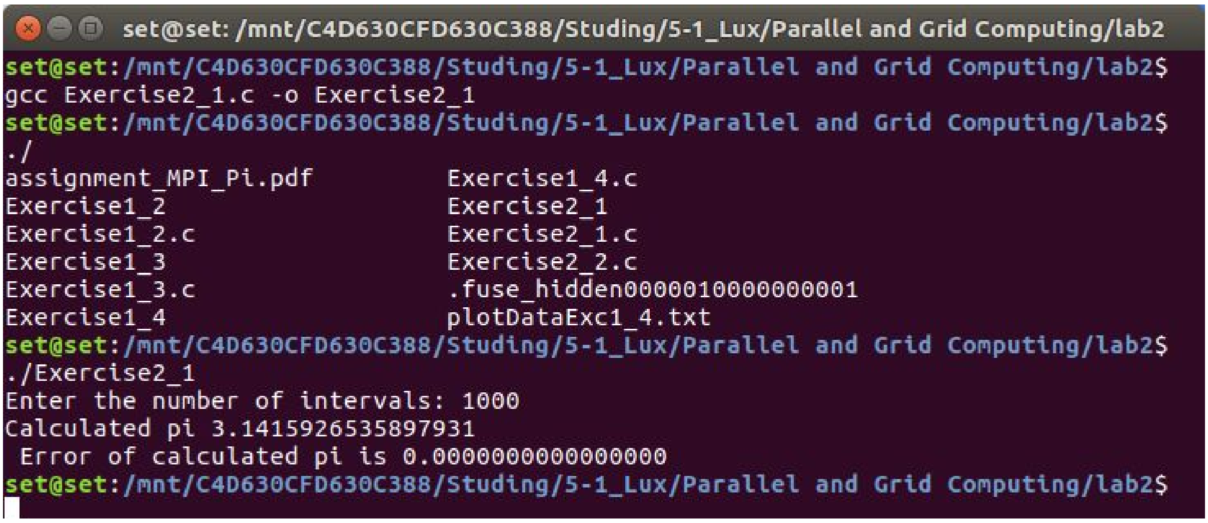
gcc Exercise2_1.c -o Exercise2_1

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$
./
assignment_MPI_Pi.pdf          Exercise1_4.c
Exercise1_2                    Exercise2_1
Exercise1_2.c                  Exercise2_1.c
Exercise1_3                    Exercise2_2.c
Exercise1_3.c                  .fuse_hidden0000010000000001
Exercise1_4                    plotDataExc1_4.txt
set@set:/mnt/C4D630CFD630C388/Studing/5-1_Lux/Parallel and Grid Computing/lab2$
./Exercise2_1
Enter the number of intervals: 1000
Calculated pi 3.1415926535897931
 Error of calculated pi is 0.0000000000000000
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

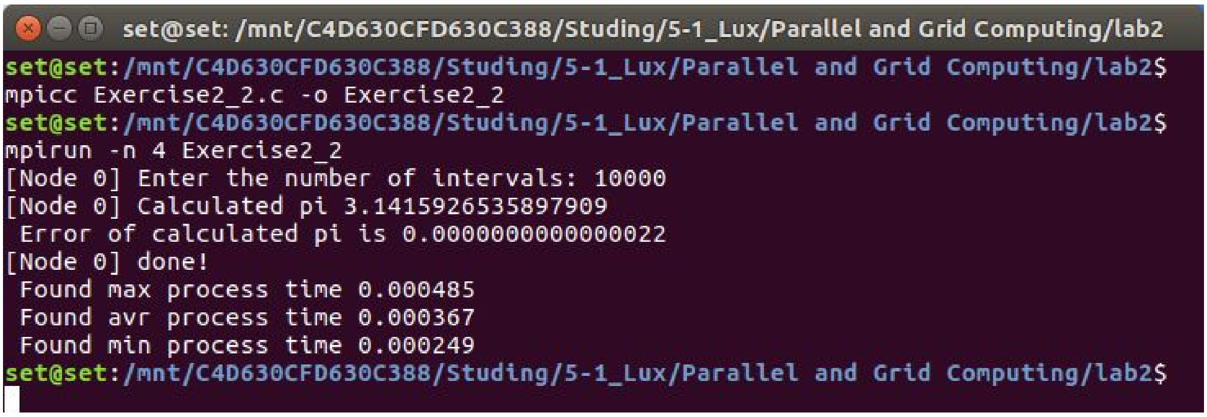
mpicc Exercise2_2.c -o Exercise2_2

Run command

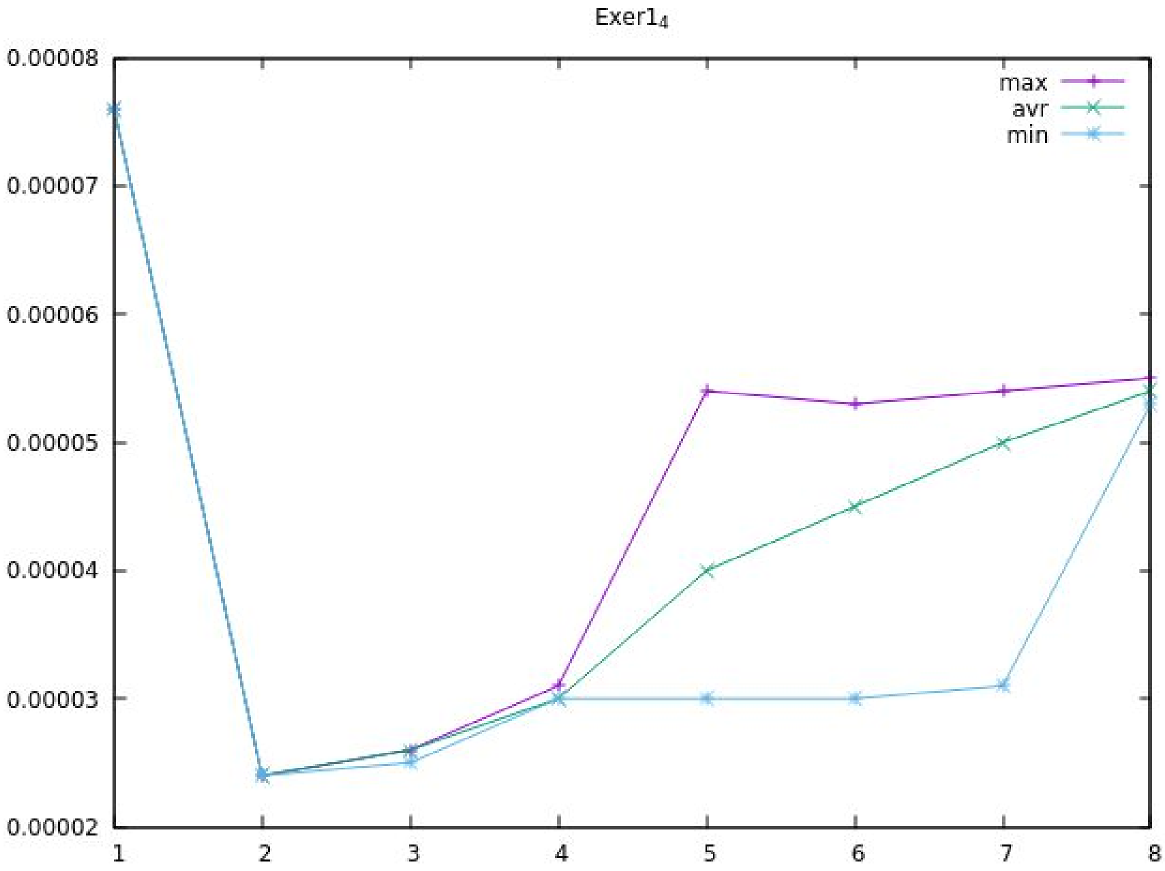
mpirun -n kolProcess ./Exercise2_2

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.c -o Exercise2_2
set@set:/mnt/C4D630CFD630C388/Studing/5-1_Lux/Parallel and Grid Computing/lab2$
mpirun -n 4 Exercise2_2
[Node 0] Enter the number of intervals: 10000
[Node 0] Calculated pi 3.1415926535897909
 Error of calculated pi is 0.0000000000000022
[Node 0] done!
 Found max process time 0.000485
 Found avr process time 0.000367
 Found min process time 0.000249
set@set:/mnt/C4D630CFD630C388/Studing/5-1_Lux/Parallel and Grid Computing/lab2$
```

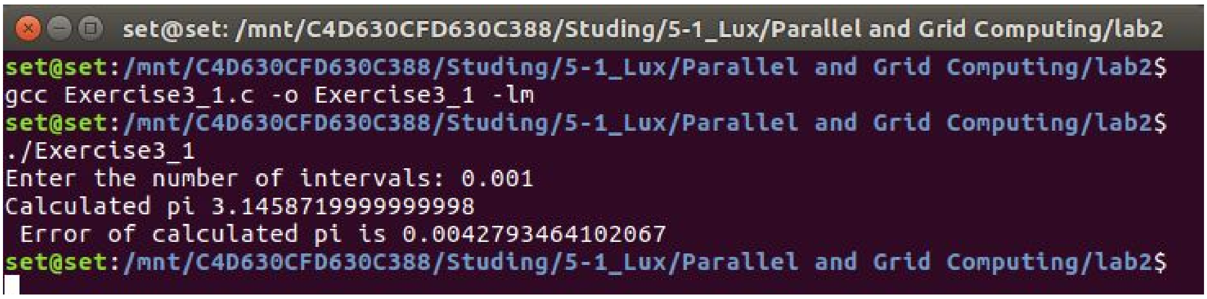


Exercise 3

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.

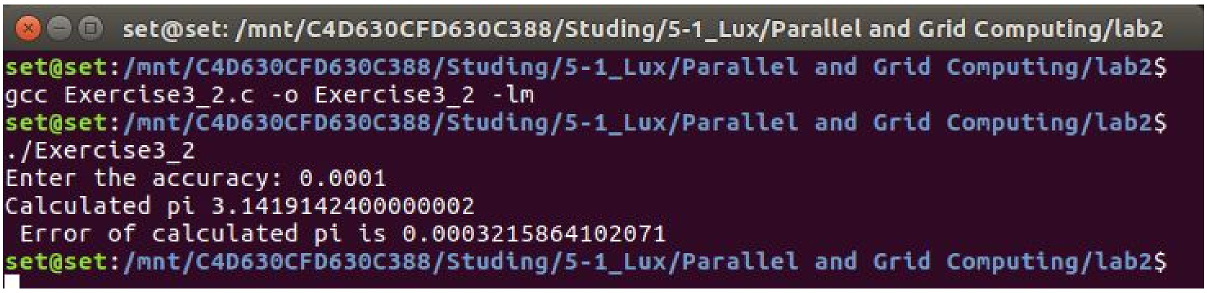

set@set: /mnt/C4D630CFD630C388/Studing/5-1_Lux/Parallel and Grid Computing/lab2

```
set@set:/mnt/C4D630CFD630C388/Studing/5-1_Lux/Parallel and Grid Computing/lab2$
gcc Exercise3_1.c -o Exercise3_1 -lm
set@set:/mnt/C4D630CFD630C388/Studing/5-1_Lux/Parallel and Grid Computing/lab2$
./Exercise3_1
Enter the number of intervals: 0.001
Calculated pi 3.1458719999999998
 Error of calculated pi is 0.0042793464102067
set@set:/mnt/C4D630CFD630C388/Studing/5-1_Lux/Parallel and Grid Computing/lab2$
```

2) Please see attached file Exercise3_2.c

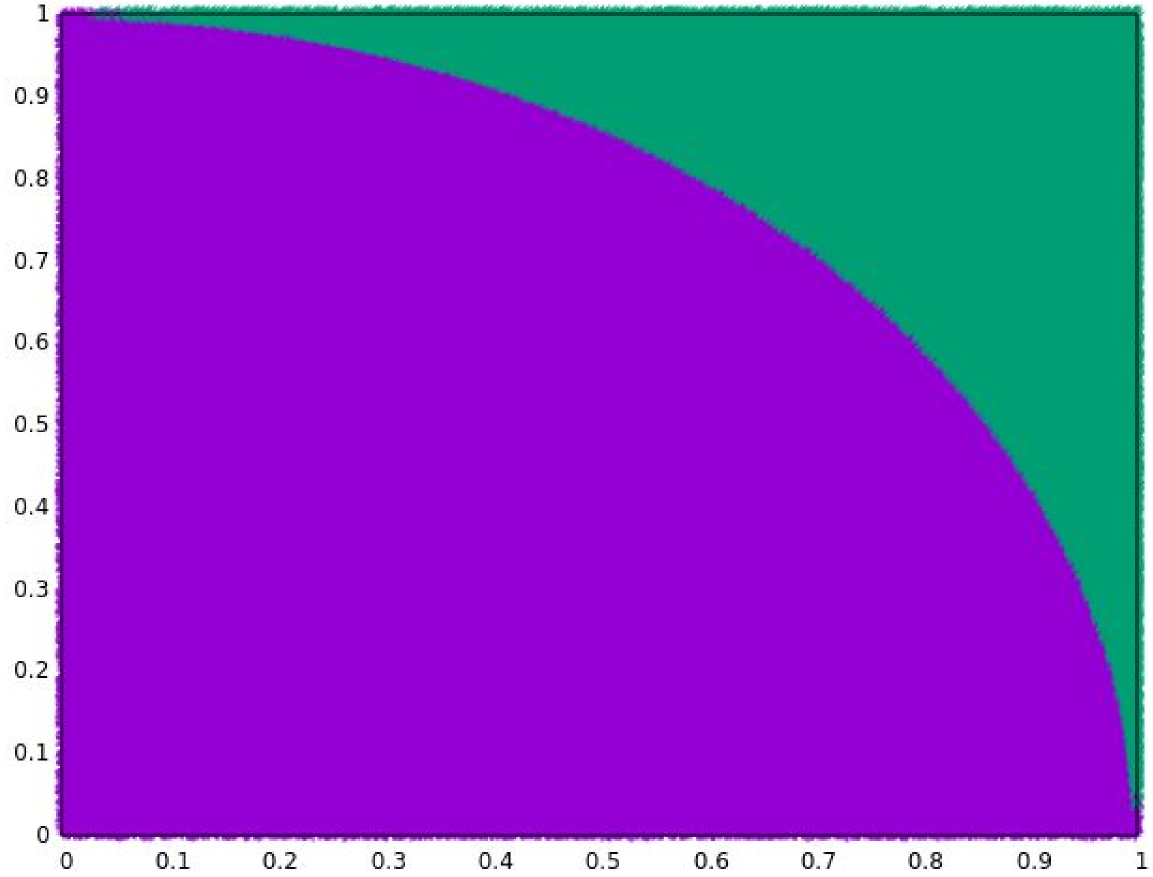
It can be compiled using command
gcc Exercise3_2.c -o Exercise3_2 -lm

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


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 Exercise3_2.c -o Exercise3_2 -lm
set@set:/mnt/C4D630CFD630C388/Studing/5-1_Lux/Parallel and Grid Computing/lab2$
./Exercise3_2
Enter the accuracy: 0.0001
Calculated pi 3.1419142400000002
 Error of calculated pi is 0.0003215864102071
set@set:/mnt/C4D630CFD630C388/Studing/5-1_Lux/Parallel and Grid Computing/lab2$
```

Plot


1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1