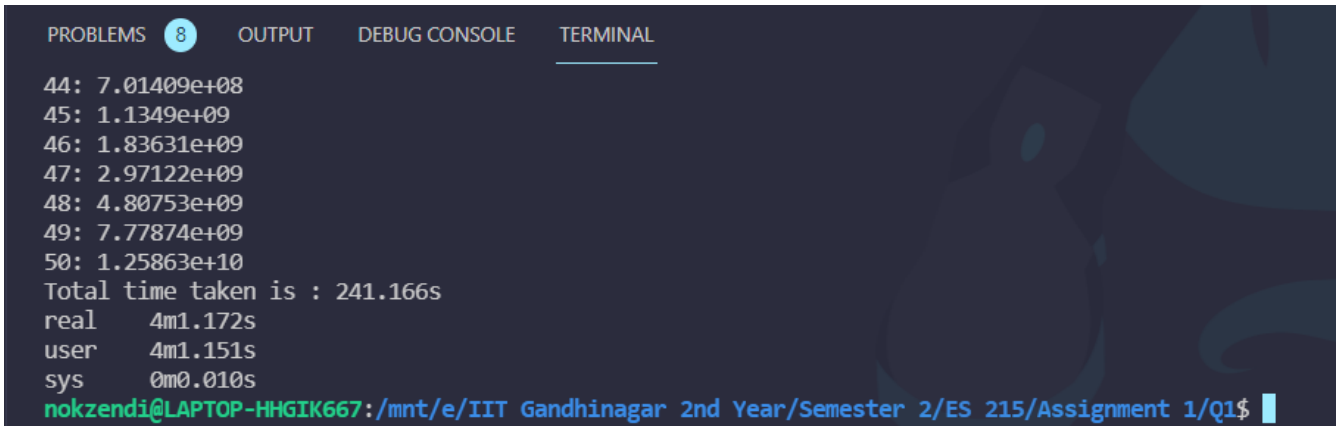
Question 1

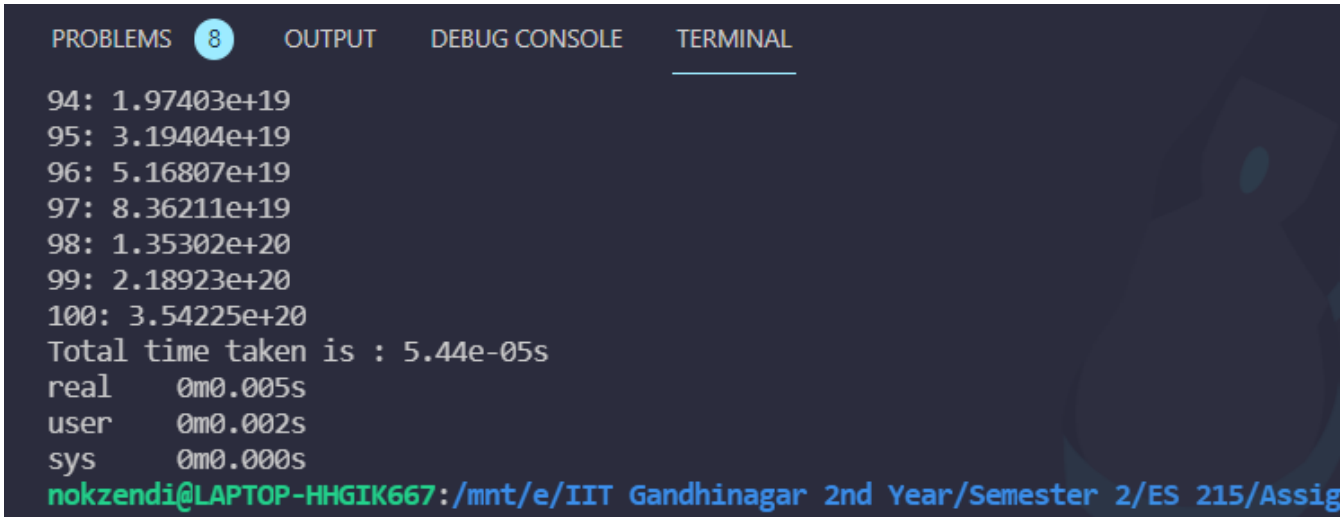
(A) Recursion:

Theoretical Execution time= Tex
Number of instructions=
Clock rate of the system=1.8 GHz
Hence,
Tex

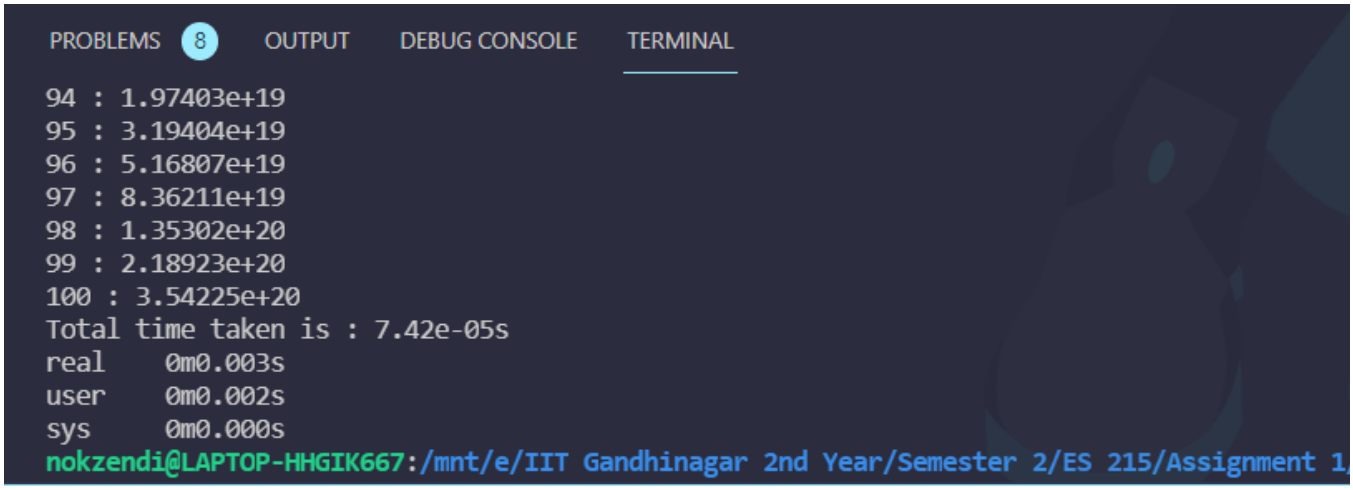


(B)Loop:

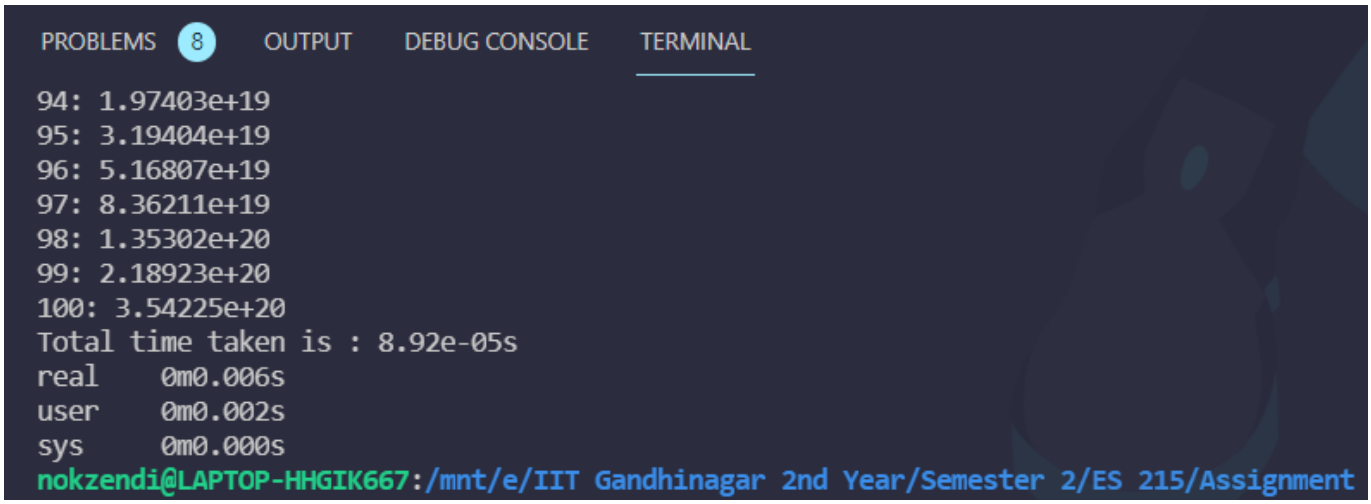
Execution time= Tb



(C) Recursion with memoization:
Execution time=Tc



(D) Loop with memoization:
Execution time= Td



Let the speedup of the programs b,c and d be Sb, Sc and Sd respectively.

Sb=Tex/Tb=
Sc=Tex/Tc=
Sd=Tex/Td=

Question 2.

Bucket 1:C++
Bucket 2:Python

Let B1(a) be double in c++

Let B1(b) be integer in c++
Let B2(a) be double in python
Let B2(b) be integer in python

(a) Execution time for:

B1(a)

N=32

```
nokzendi@LAPTOP-HHGIK667:/mnt/e/IIT Gandhinagar 2nd Year/Semester 2/ES
nokzendi@LAPTOP-HHGIK667:/mnt/e/IIT Gandhinagar 2nd Year/Semester 2/ES
Total time taken is : 0.0003583s
real    0m0.005s
user    0m0.002s
sys     0m0.000s
nokzendi@LAPTOP-HHGIK667:/mnt/e/IIT Gandhinagar 2nd Year/Semester 2/ES
```

System time = 0s
Total CPU time = user +sys = 0.002s
Total execution time = 0.005s
Execution time for the meat part of the program = 0.0003583s
Total Execution time/ Time for meat portions = 13.9547

N=64

```
nokzendi@LAPTOP-HHGIK667:/mnt/e/IIT Gandhinagar 2nd Year/Semester 2
nokzendi@LAPTOP-HHGIK667:/mnt/e/IIT Gandhinagar 2nd Year/Semester 2
Total time taken is : 0.0027519s
real    0m0.008s
user    0m0.005s
sys     0m0.000s
nokzendi@LAPTOP-HHGIK667:/mnt/e/IIT Gandhinagar 2nd Year/Semester 2
```

System time = 0s
Total CPU time = user +sys = 0.005s
Total execution time = 0.008s
Execution time for the meat part of the program = 0.0027519s
Total Execution time/ Time for meat portions = 2.90

N=128

```
nokzendi@LAPTOP-HHGIK667:/mnt/e/IIT Gandhinagar 2nd Year/Semester 2/ES 215/Assignment 1/Q2$ g++ matri
nokzendi@LAPTOP-HHGIK667:/mnt/e/IIT Gandhinagar 2nd Year/Semester 2/ES 215/Assignment 1/Q2$ time ./a.
Total time taken is : 0.0223157s
real    0m0.030s
user    0m0.026s
sys     0m0.000s
nokzendi@LAPTOP-HHGIK667:/mnt/e/IIT Gandhinagar 2nd Year/Semester 2/ES 215/Assignment 1/Q2$
```

System time = 0s
Total CPU time = user +sys = 0.026s

Total execution time = 0.030s
Execution time for the meat part of the program = 0.0223157s
Total Execution time/ Time for meat portions = 1.3443

N=256

```
nokzendi@LAPTOP-HHGIK667:/mnt/e/IIT Gandhinagar 2nd Year/Semester 2/ES 215/Assignment 1/Q2$ g++ matrix_doubl
nokzendi@LAPTOP-HHGIK667:/mnt/e/IIT Gandhinagar 2nd Year/Semester 2/ES 215/Assignment 1/Q2$ time ./a.out
Total time taken is : 0.183882s
real    0m0.191s
user    0m0.188s
sys     0m0.000s
nokzendi@LAPTOP-HHGIK667:/mnt/e/IIT Gandhinagar 2nd Year/Semester 2/ES 215/Assignment 1/Q2$ DS
```

System time = 0s
Total CPU time = user +sys = 0.188s
Total execution time = 0.191
Execution time for the meat part of the program = 0.18388s
Total Execution time/ Time for meat portions = 1.0387

N=512

```
nokzendi@LAPTOP-HHGIK667:/mnt/e/IIT Gandhinagar 2nd Year/Semester 2/ES 215/Assignment 1/Q2$ g++ matrix_double.cpp
nokzendi@LAPTOP-HHGIK667:/mnt/e/IIT Gandhinagar 2nd Year/Semester 2/ES 215/Assignment 1/Q2$ time ./a.out
Total time taken is : 1.62638s
real    0m1.638s
user    0m1.635s
sys     0m0.000s
nokzendi@LAPTOP-HHGIK667:/mnt/e/IIT Gandhinagar 2nd Year/Semester 2/ES 215/Assignment 1/Q2$
```

System time = 0s
Total CPU time = user +sys = 1.635s
Total execution time = 1.635s
Execution time for the meat part of the program = 1.62638s
Total Execution time/ Time for meat portions = 1.0053

B1(b)
N=32

```
nokzendi@LAPTOP-HHGIK667:/mnt/e/IIT Gandhinagar 2nd Year/Semester 2/ES 215/Assignment 1/Q2$ g++ matrix.cpp
nokzendi@LAPTOP-HHGIK667:/mnt/e/IIT Gandhinagar 2nd Year/Semester 2/ES 215/Assignment 1/Q2$ time ./a.out
Total time taken for product is : 0.0005723s
real    0m0.007s
user    0m0.002s
sys     0m0.000s
nokzendi@LAPTOP-HHGIK667:/mnt/e/IIT Gandhinagar 2nd Year/Semester 2/ES 215/Assignment 1/Q2$
```

System time = 0s
Total CPU time = user +sys = 0.002s
Total execution time = 0.007s
Execution time for the meat part of the program = 0.0005723s

Total Execution time/ Time for meat portions = 12.2313

N=64

```
nokzendi@LAPTOP-HHGIK667:/mnt/e/IIT Gandhinagar 2nd Year/Semester 2/ES 215/Assignment 1/Q2$ g++
nokzendi@LAPTOP-HHGIK667:/mnt/e/IIT Gandhinagar 2nd Year/Semester 2/ES 215/Assignment 1/Q2$ tim
Total time taken for product is : 0.0045959s
real    0m0.012s
user    0m0.000s
sys     0m0.008s
nokzendi@LAPTOP-HHGIK667:/mnt/e/IIT Gandhinagar 2nd Year/Semester 2/ES 215/Assignment 1/Q2$
```

System time = 0.008s
Total CPU time = user +sys = 0.008s
Total execution time = 0.012s
Execution time for the meat part of the program = 0.0045959s
Total Execution time/ Time for meat portions = 2.611

N=128

```
nokzendi@LAPTOP-HHGIK667:/mnt/e/IIT Gandhinagar 2nd Year/Semester 2/ES 215/Assignment 1/Q2$ g++ m
nokzendi@LAPTOP-HHGIK667:/mnt/e/IIT Gandhinagar 2nd Year/Semester 2/ES 215/Assignment 1/Q2$ time
Total time taken for product is : 0.035806s
real    0m0.044s
user    0m0.039s
sys     0m0.000s
nokzendi@LAPTOP-HHGIK667:/mnt/e/IIT Gandhinagar 2nd Year/Semester 2/ES 215/Assignment 1/Q2$
```

System time = 0s
Total CPU time = user +sys = 0.039s
Total execution time = 0.044s
Execution time for the meat part of the program = 0.035806s
Total Execution time/ Time for meat portions = 1.228

N=256

```
nokzendi@LAPTOP-HHGIK667:/mnt/e/IIT Gandhinagar 2nd Year/Semester 2/ES 215/Assignment 1/Q2$ g++ m
nokzendi@LAPTOP-HHGIK667:/mnt/e/IIT Gandhinagar 2nd Year/Semester 2/ES 215/Assignment 1/Q2$ time
Total time taken for product is : 0.244243s
real    0m0.253s
user    0m0.249s
sys     0m0.000s
nokzendi@LAPTOP-HHGIK667:/mnt/e/IIT Gandhinagar 2nd Year/Semester 2/ES 215/Assignment 1/Q2$
```

System time = 0.0s
Total CPU time = user +sys = 0.249s
Total execution time = 0.253s
Execution time for the meat part of the program = 0.244243s
Total Execution time/ Time for meat portions = 1.03

N=512

```
nokzendi@LAPTOP-HHGIK667:/mnt/e/IIT Gandhinagar 2nd Year/Semester 2/ES 215/Assignment 1/Q2$ g++ ma
nokzendi@LAPTOP-HHGIK667:/mnt/e/IIT Gandhinagar 2nd Year/Semester 2/ES 215/Assignment 1/Q2$ time .
Total time taken for product is : 1.48441s
real    0m1.495s
user    0m1.492s
sys     0m0.000s
nokzendi@LAPTOP-HHGIK667:/mnt/e/IIT Gandhinagar 2nd Year/Semester 2/ES 215/Assignment 1/Q2$
```

System time = 0s
Total CPU time = user +sys = 1.492s
Total execution time = 1.495s
Execution time for the meat part of the program = 1.48441s
Total Execution time/ Time for meat portions = 1.0071

B2(a)
N=32

```
nokzendi@LAPTOP-HHGIK667:/mnt/e/IIT Gandhinagar 2nd Year/Semester 2/ES 215/Assignment 1/Q2$ time python3 matrix_double.py
Time :  0.007351099997322308

real    0m0.048s
user    0m0.025s
sys     0m0.012s
nokzendi@LAPTOP-HHGIK667:/mnt/e/IIT Gandhinagar 2nd Year/Semester 2/ES 215/Assignment 1/Q2$
```

System time = 0.012s
Total CPU time = user +sys = 0.037s
Total execution time = 0.048s
Execution time for the meat part of the program = 0.007351
Total Execution time/ Time for meat portions = 6.529

N=64

```
nokzendi@LAPTOP-HHGIK667:/mnt/e/IIT Gandhinagar 2nd Year/Semester 2/ES 215/Assignment 1/Q2$ time python3 matrix_double.py
Time :  0.05941769999844837

real    0m0.108s
user    0m0.080s
sys     0m0.010s
nokzendi@LAPTOP-HHGIK667:/mnt/e/IIT Gandhinagar 2nd Year/Semester 2/ES 215/Assignment 1/Q2$
```

System time = 0.10s
Total CPU time = user +sys = 0.90s
Total execution time = 0.100s
Execution time for the meat part of the program = 0.05941s
Total Execution time/ Time for meat portions = 1.6832

N=128

```
nokzendi@LAPTOP-HHGIK667:/mnt/e/IIT Gandhinagar 2nd Year/Semester 2/ES 215/Assignment 1/Q2$ time python3 matrix_double.py
Time :  1.2634218000021065

real    0m1.326s
user    0m1.292s
sys     0m0.020s
nokzendi@LAPTOP-HHGIK667:/mnt/e/IIT Gandhinagar 2nd Year/Semester 2/ES 215/Assignment 1/Q2$
```

System time = 0.020s
Total CPU time = user +sys = 1.312s
Total execution time = 1.326s
Execution time for the meat part of the program = 1.263421s
Total Execution time/ Time for meat portions = 1.0495

N=256

```
nokzendi@LAPTOP-HHGIK667:/mnt/e/IIT Gandhinagar 2nd Year/Semester 2/ES 215/Assignment 1/Q2$ time python3 matrix_double.py
Time :  3.6909567000002426

real    0m3.807s
user    0m3.783s
sys     0m0.010s
nokzendi@LAPTOP-HHGIK667:/mnt/e/IIT Gandhinagar 2nd Year/Semester 2/ES 215/Assignment 1/Q2$
```

System time = 0.010s
Total CPU time = user +sys = 3.793s
Total execution time = 3.807s
Execution time for the meat part of the program = 3.690956s
Total Execution time/ Time for meat portions = 1.03144

N=512

```
nokzendi@LAPTOP-HHGIK667:/mnt/e/IIT Gandhinagar 2nd Year/Semester 2/ES 215/Assignment 1/Q2$ time python3 matrix_double.py
Time :  39.401155100000324

real    0m39.852s
user    0m39.817s
sys     0m0.020s
nokzendi@LAPTOP-HHGIK667:/mnt/e/IIT Gandhinagar 2nd Year/Semester 2/ES 215/Assignment 1/Q2$
```

System time = 0.020s
Total CPU time = user +sys = 39.837s
Total execution time = 39.852s
Execution time for the meat part of the program = 38.401155s
Total Execution time/ Time for meat portions = 1.0377

B2(b)
N=32

```
nokzendi@LAPTOP-HHGIK667:/mnt/e/IIT Gandhinagar 2nd Year/Semester 2/ES 215/Assignment 1/Q2$ time python3 matrix.py
Time :  0.015717700000095647

real    0m0.065s
user    0m0.043s
sys     0m0.009s
nokzendi@LAPTOP-HHGIK667:/mnt/e/IIT Gandhinagar 2nd Year/Semester 2/ES 215/Assignment 1/Q2$
```

System time = 0.009s
Total CPU time = user +sys = 0.052s
Total execution time = 0.065s

Execution time for the meat part of the program = 0.0157177s
Total Execution time/ Time for meat portions = 4.1354

N=64

```
nokzendi@LAPTOP-HHGIK667:/mnt/e/IIT Gandhinagar 2nd Year/Semester 2/ES 215/Assignment 1/Q2$ time python3 matrix.py
Time :  0.10569140000006882

real    0m0.163s
user    0m0.134s
sys     0m0.010s
nokzendi@LAPTOP-HHGIK667:/mnt/e/IIT Gandhinagar 2nd Year/Semester 2/ES 215/Assignment 1/Q2$
```

System time = 0.010s
Total CPU time = user +sys = 0.144s
Total execution time = 0.163s
Execution time for the meat part of the program = 0.105691s
Total Execution time/ Time for meat portions = 1.5422

N=128

```
nokzendi@LAPTOP-HHGIK667:/mnt/e/IIT Gandhinagar 2nd Year/Semester 2/ES 215/Assignment 1/Q2$ time python3 matrix.py
Time :  1.4322458000024199

real    0m1.527s
user    0m1.515s
sys     0m0.000s
nokzendi@LAPTOP-HHGIK667:/mnt/e/IIT Gandhinagar 2nd Year/Semester 2/ES 215/Assignment 1/Q2$
```

System time = 0s
Total CPU time = user +sys = 1.515s
Total execution time = 1.527s
Execution time for the meat part of the program = 1.432245s
Total Execution time/ Time for meat portions = 1.06615

N=256

```
nokzendi@LAPTOP-HHGIK667:/mnt/e/IIT Gandhinagar 2nd Year/Semester 2/ES 215/Assignment 1/Q2$ time python3 matrix.py
Time :  6.088838600000599

real    0m6.575s
user    0m6.551s
sys     0m0.010s
nokzendi@LAPTOP-HHGIK667:/mnt/e/IIT Gandhinagar 2nd Year/Semester 2/ES 215/Assignment 1/Q2$
```

System time = 0.010s
Total CPU time = user +sys = 6.561s
Total execution time = 6.575s
Execution time for the meat part of the program = 6.088838s
Total Execution time/ Time for meat portions = 1.0798

N=512

```
nokzendi@LAPTOP-HHGIK667:/mnt/e/IIT Gandhinagar 2nd Year/Semester 2/ES 215/Assignment 1/Q2$ time python3 matrix.py
Time :  54.21769010000207

real    0m55.034s
user    0m54.893s
sys     0m0.130s
nokzendi@LAPTOP-HHGIK667:/mnt/e/IIT Gandhinagar 2nd Year/Semester 2/ES 215/Assignment 1/Q2$
```

System time = 0.130s
Total CPU time = user +sys = 55.023s
Total execution time = 55.034s
Execution time for the meat part of the program = 54.2176901s
Total Execution time/ Time for meat portions = 1.01