

## ES215: Computer Organisation and Architecture

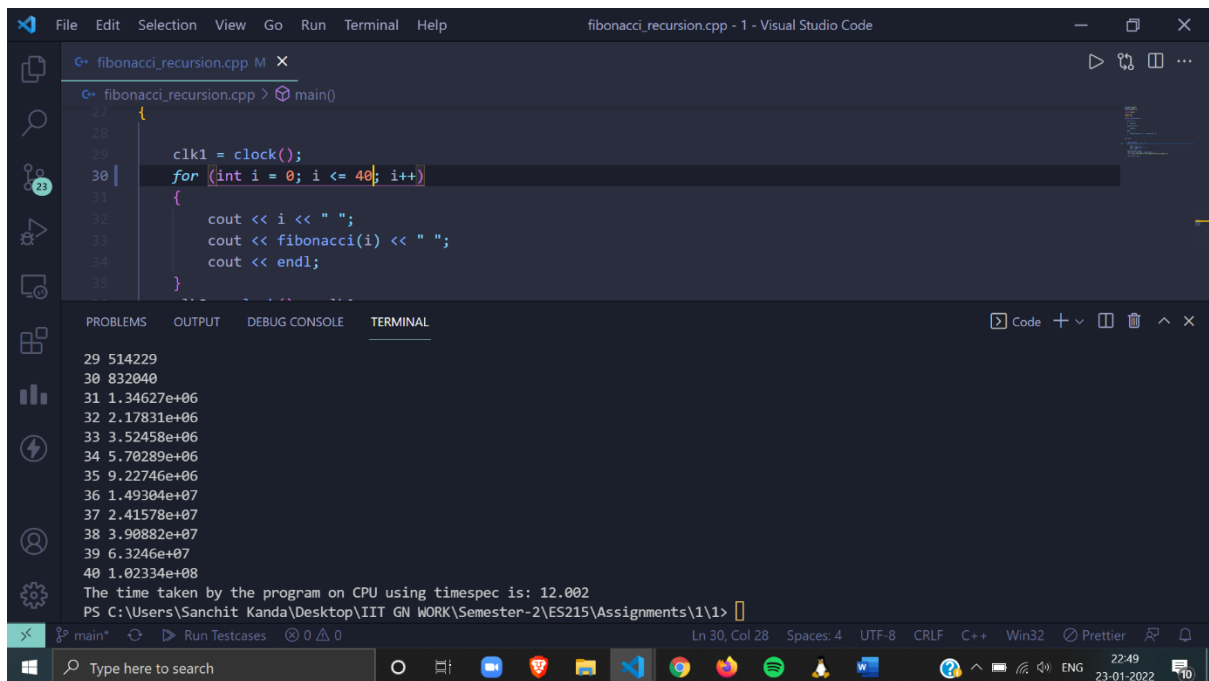
([https://github.com/Madhav-Kanda/ES215\\_Assignment\\_1](https://github.com/Madhav-Kanda/ES215_Assignment_1))

Q1.

a) Time taken using recursion: **133,605.45 sec**

Time taken for first 40 fibonacci = **12.002 sec**

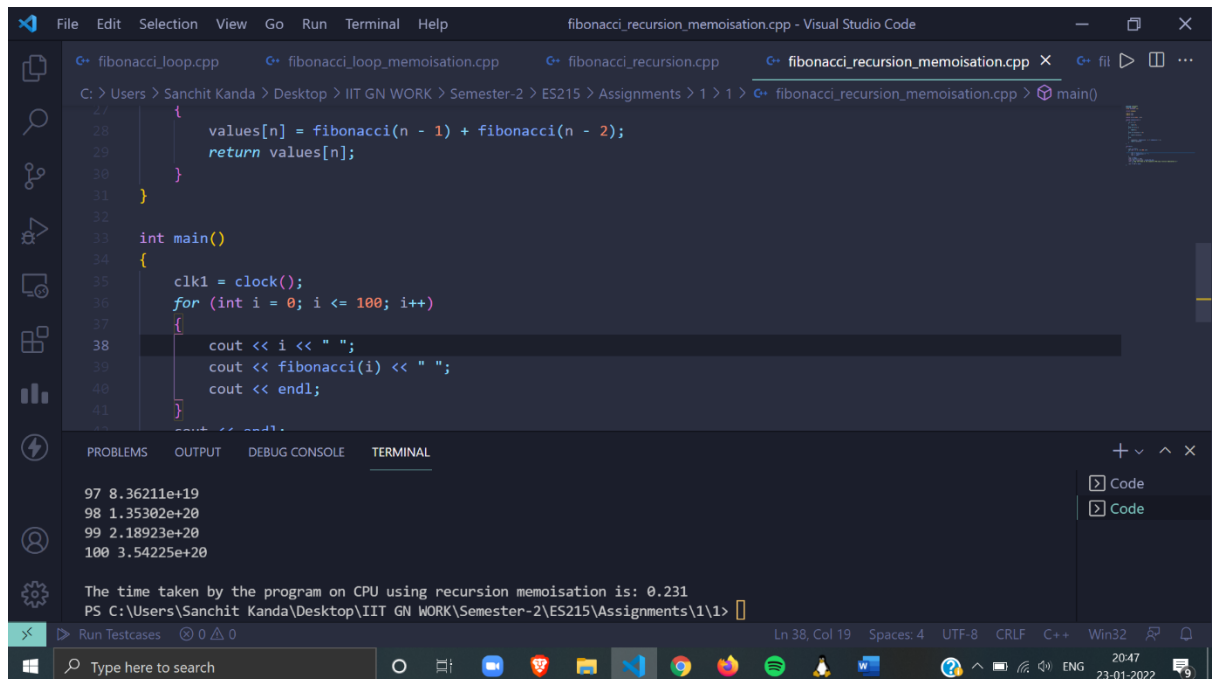
Formula to calculate time taken for 100 fibonacci =  $((1.168)^{(60))) * (12.002)$  sec



```
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fibonacci_recursion.cpp - 1 - Visual Studio Code

fibonacci_recursion.cpp M X
27 {
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29     clk1 = clock();
30     for (int i = 0; i <= 40; i++)
31     {
32         cout << i << " ";
33         cout << fibonacci(i) << " ";
34         cout << endl;
35     }
36 }
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```

c) Time taken using recursion and memoization: **0.231s**

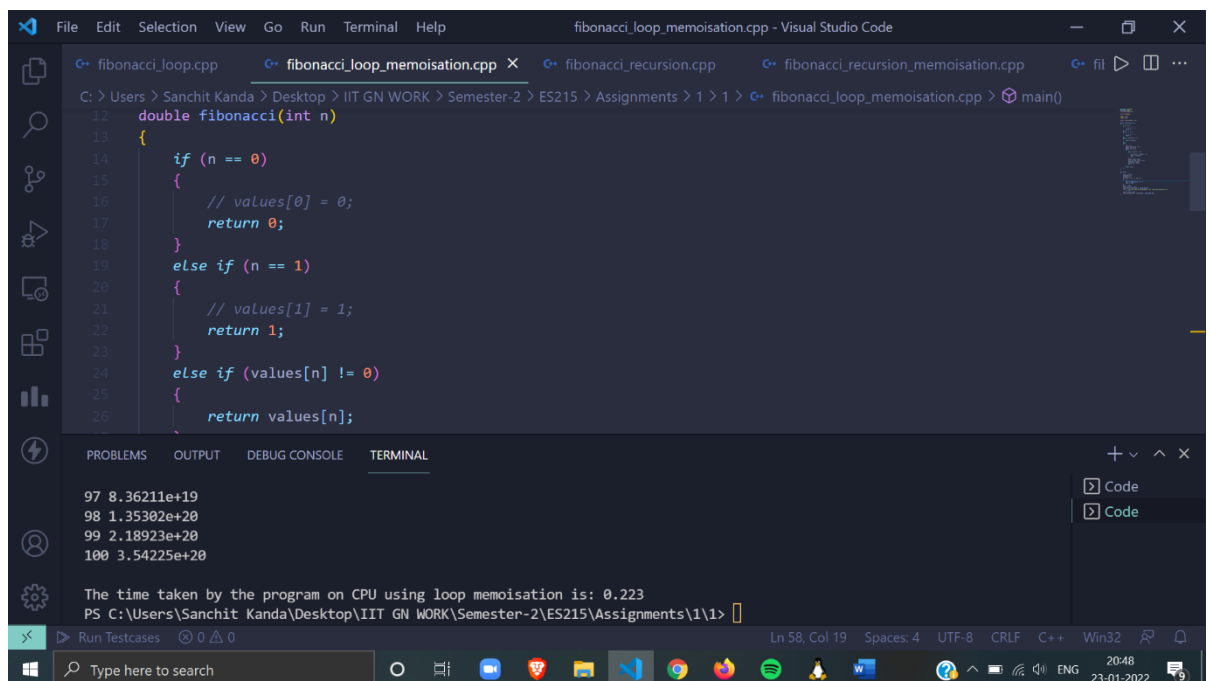


```
fibonacci_recursion_memoisation.cpp - Visual Studio Code
C:\Users\Sanchit Kanda\Desktop\IIT GN WORK\Semester-2\ES215\Assignments\1\1> G++ fibonacci_recursion_memoisation.cpp > main()
27     values[n] = fibonacci(n - 1) + fibonacci(n - 2);
28     return values[n];
29 }
30 }
31 }
32 }
33 int main()
34 {
35     clk1 = clock();
36     for (int i = 0; i <= 100; i++)
37     {
38         cout << i << " ";
39         cout << fibonacci(i) << " ";
40         cout << endl;
41     }
42     cout << endl;
43 }
```

97 8.36211e+19  
98 1.35302e+20  
99 2.18923e+20  
100 3.54225e+20

The time taken by the program on CPU using recursion memoisation is: 0.231  
PS C:\Users\Sanchit Kanda\Desktop\IIT GN WORK\Semester-2\ES215\Assignments\1\1>

d) Time taken using loop memoization: **0.223s**



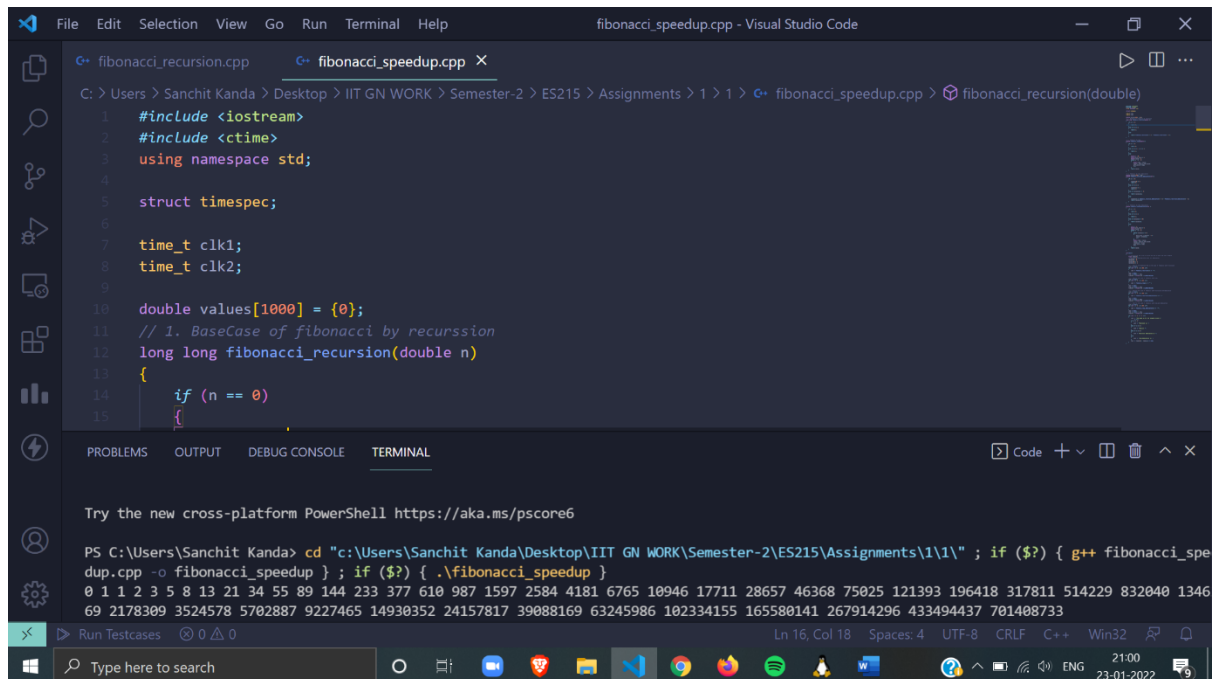
```
fibonacci_loop_memoisation.cpp - Visual Studio Code
C:\Users\Sanchit Kanda\Desktop\IIT GN WORK\Semester-2\ES215\Assignments\1\1> G++ fibonacci_loop_memoisation.cpp > main()
12 double fibonacci(int n)
13 {
14     if (n == 0)
15     {
16         // values[0] = 0;
17         return 0;
18     }
19     else if (n == 1)
20     {
21         // values[1] = 1;
22         return 1;
23     }
24     else if (values[n] != 0)
25     {
26         return values[n];
27     }
28 }
```

97 8.36211e+19  
98 1.35302e+20  
99 2.18923e+20  
100 3.54225e+20

The time taken by the program on CPU using loop memoisation is: 0.223  
PS C:\Users\Sanchit Kanda\Desktop\IIT GN WORK\Semester-2\ES215\Assignments\1\1>

Speedup of all the program:

- Speedup for recursion is:  $(\text{Time taken using recursion} / \text{Time taken using recursion}) = 1$
- Speedup for loop is:  $(\text{Time taken using recursion} / \text{Time taken using loop}) =$
- Speedup for recursion and memoisation is:
- Speedup for loop memoisation is:



```
fibonacci_recursion.cpp  fibonacci_speedup.cpp X
C: > Users > Sanchit Kanda > Desktop > IIT GN WORK > Semester-2 > ES215 > Assignments > 1 > 1 > fibonacci_speedup.cpp > fibonacci_recursion(double)
1  #include <iostream>
2  #include <ctime>
3  using namespace std;
4
5  struct timespec;
6
7  time_t clk1;
8  time_t clk2;
9
10 double values[1000] = {0};
11 // 1. BaseCase of fibonacci by recursion
12 long long fibonacci_recursion(double n)
13 {
14     if (n == 0)
15     {
```

Try the new cross-platform PowerShell <https://aka.ms/pscore6>

```
PS C:\Users\Sanchit Kanda> cd "c:\Users\Sanchit Kanda\Desktop\IIT GN WORK\Semester-2\ES215\Assignments\1\1\" ; if ($?) { g++ fibonacci_speedup.cpp -o fibonacci_speedup } ; if ($?) { .\fibonacci_speedup }
0 1 1 2 3 5 8 13 21 34 55 89 144 233 377 610 987 1597 2584 4181 6765 10946 17711 28657 46368 75025 121393 196418 317811 514229 832040 134669 2178309 3524578 5702887 9227465 14930352 24157817 39088169 63245986 102334155 165580141 267914296 433494437 701408733
```

Q2.

## A) Output Time

CPU Time=user +sys

a) For C++ using Double

1. N=32

```
real    0m1.675s
user    0m0.016s
sys     0m0.000s
```

2. N=64

```
real    0m1.413s
user    0m0.000s
sys     0m0.000s
```

3. N=128

```
real    0m1.439s
user    0m0.031s
sys     0m0.047s
```

4. N=256

```
real    0m1.760s
user    0m0.078s
sys     0m0.047s
```

5. N=512

```
real    0m3.858s
user    0m0.781s
sys     0m0.016s
```

**b) For C++ using Integer**

1. N=32

```
real    0m0.719s
user    0m0.000s
sys     0m0.000s
```

2. N=64

```
real    0m1.026s
user    0m0.016s
sys     0m0.000s
```

3. N=128

```
real    0m1.267s
user    0m0.016s
sys     0m0.000s
```

4. N=256

```
real    0m2.311s
user    0m0.156s
sys     0m0.000s
```

5. N=512

```
real    0m3.572s
user    0m0.766s
sys     0m0.047s
```

a) For Python using integer

1. N=32

```
real    0m3.512s
user    0m0.031s
sys     0m0.031s
```

2. N=64

```
real    0m3.905s
user    0m0.078s
sys     0m0.031s
```

3. N=128

```
real    0m2.539s
user    0m0.484s
sys     0m0.000s
```

4. N=256

```
real    0m5.792s
user    0m3.406s
sys     0m0.047s
```

5. N=512

```
real    0m32.467s
user    0m30.344s
sys     0m0.078s
```

**b) For Python using Double**

1. N=32

```
real    0m1.257s
user    0m0.047s
sys     0m0.016s
```

2. N=64

```
real    0m1.555s
user    0m0.078s
sys     0m0.031s
```

3. N=128

```
real    0m2.119s
user    0m0.406s
sys     0m0.078s
```

4. N=256

```
real    0m4.258s
user    0m3.406s
sys     0m0.031s
```

5. N=512

```
real    0m32.619s
user    0m30.641s
sys     0m0.125s
```

**B)**

a) C++ program for integer

1. N=32

Execution Time: 3.757s

Meat Portion: 0.015625s

(Meat Portion/Execution Time): 0.00415

```
The time taken by the meat portion of the program is: 0.015625
```

```
real    0m3.757s
user    0m0.031s
sys     0m0.000s
```

```
madhav@LAPTOP-RUM7KR1E:/mnt/c/Users/Sanchit Kanda/Desktop/IIT GN WORK/Semester-2/ES215/Assignments/1/2$
```

2. N=64

Execution Time: 1.641s

Meat Portion: 0.015625s

(Meat Portion/Execution Time): 0.009521

```
The time taken by the meat portion of the program is: 0.015625  
real    0m1.641s  
user    0m0.016s  
sys     0m0.000s  
madhav@LAPTOP-RUM7KR1E:/mnt/c/Users/Sanchit Kanda/Desktop/IIT GN WORK/Semester-2/ES215/Assignments/1/2$ time ./a.out
```

3. N=128

Execution Time: 4.554s

Meat Portion: 0.046875s

(Meat Portion/Execution Time): 0.0102

```
The time taken by the meat portion of the program is: 0.046875  
real    0m4.554s  
user    0m0.031s  
sys     0m0.031s  
madhav@LAPTOP-RUM7KR1E:/mnt/c/Users/Sanchit Kanda/Desktop/IIT G
```

4. N=256

Execution Time: 2.150s

Meat Portion: 0.09375s

(Meat Portion/Execution Time): 0.043

```
The time taken by the meat portion of the program is: 0.09375  
real    0m2.150s  
user    0m0.063s  
sys     0m0.031s  
madhav@LAPTOP-RUM7KR1E:/mnt/c/Users/Sanchit Kanda/Desktop/IIT
```

5. N=512

Execution Time: 6.323s



Meat Portion: 0.84375s

(Meat Portion/Execution Time): 0.133

```
The time taken by the meat portion of the program is: 0.84375

real    0m6.323s
user    0m0.797s
sys     0m0.063s
madhav@LAPTOP-RUM7KR1E:/mnt/c/Users/Sanchit Kanda/Desktop/IIT
```

## b) C++ program for double

1. N=32

Execution Time: 1.278s

Meat Portion: 0.015625s

(Meat Portion/Execution Time): 0.1222

```
The time taken by the meat portion of the program is: 0.015625

real    0m1.278s
user    0m0.000s
sys     0m0.016s
madhav@LAPTOP-RUM7KR1E:/mnt/c/Users/Sanchit Kanda/Desktop/IIT G
```

2. N=64

Execution Time: 0.932s

Meat Portion: 0.015625s

(Meat Portion/Execution Time): 0.0167

```
The time taken by the meat portion of the program is: 0.015625

real    0m0.932s
user    0m0.000s
sys     0m0.016s
madhav@LAPTOP-RUM7KR1E:/mnt/c/Users/Sanchit Kanda/Desktop/IIT G
```

3. N=128

Execution Time: 1.373s

Meat Portion: 0.015625s

(Meat Portion/Execution Time): 0.0113

```
The time taken by the meat portion of the program is: 0.015625  
  
real    0m1.373s  
user    0m0.000s  
sys     0m0.016s  
madhav@LAPTOP-RUM7KR1E:/mnt/c/Users/Sanchit Kanda/Desktop/IIT G
```

4. N=256

Execution Time: 3.026s

Meat Portion: 0.171875s

(Meat Portion/Execution Time): 0.056799

```
The time taken by the meat portion of the program is: 0.171875  
  
real    0m3.026s  
user    0m0.141s  
sys     0m0.031s  
madhav@LAPTOP-RUM7KR1E:/mnt/c/Users/Sanchit Kanda/Desktop/IIT G
```

5. N=512

Execution Time: 3.894s

Meat Portion: 1.0156s

(Meat Portion/Execution Time): 0.2608

```
The time taken by the meat portion of the program is: 1.01562  
  
real    0m3.894s  
user    0m0.969s  
sys     0m0.078s  
madhav@LAPTOP-RUM7KR1E:/mnt/c/Users/Sanchit Kanda/Desktop/IIT
```

### a) Python program for Double

1. N=32

Execution Time: 1.126s

Meat Portion: 0.0110s

(Meat Portion/Execution Time): 0.00976

```
Meat portion time : 0.01101470000048721

real    0m1.126s
user    0m0.047s
sys     0m0.000s
madhav@LAPTOP-RUM7KR1E:/mnt/c/Users/Sanchit Ka
```

2. N=64

Execution Time: 0.806s

Meat Portion: 0.05487s

(Meat Portion/Execution Time): 0.067

```
Meat portion time : 0.054873699999916425

real    0m0.806s
user    0m0.094s
sys     0m0.000s
madhav@LAPTOP-RUM7KR1E:/mnt/c/Users/Sanchi
```

3. N=128

Execution Time: 1.769s

Meat Portion: 0.403s

(Meat Portion/Execution Time): 0.2278

```
Meat portion time : 0.4038940000000366

real    0m1.769s
user    0m0.438s
sys     0m0.000s
madhav@LAPTOP-RUM7KR1E: /mnt/c/Users/Sanch
```

4. N=256

Execution Time: 4.882s

Meat Portion: 3.392s

(Meat Portion/Execution Time): 0.69

```
Meat portion time : 3.3926918999995905

real    0m4.882s
user    0m3.438s
sys     0m0.031s
madhav@LAPTOP-RUM7KR1E: /mnt/c/Users/Sanch
```

5. N=512

Execution Time: 32.378s

Meat Portion: 31.07s

(Meat Portion/Execution Time): 0.95

```
Meat portion time : 31.07839149999927

real    0m32.378s
user    0m30.859s
sys     0m0.141s
madhav@LAPTOP-RUM7KR1E: /mnt/c/Users/Sanch
```

## b)Python program for Integer

1. N=32

Execution Time: 1.216s

Meat Portion: 0.0107s

(Meat Portion/Execution Time): 0.087

```
Time : 0.010749000000032538

real    0m1.216s
user    0m0.031s
sys     0m0.016s
madhav@LAPTOP-RUM7KR1E: /mnt/c
```

2. N=64

Execution Time: 1.736s

Meat Portion: 0.0566s

(Meat Portion/Execution Time): 0.032

```
Time : 0.056670999999936909

real    0m1.736s
user    0m0.063s
sys     0m0.031s
```

3. N=128

Execution Time: 1.306s

Meat Portion: 0.489s

(Meat Portion/Execution Time): 0.37

```
Time : 0.48954700000012963
```

```
real    0m1.306s
```

```
user    0m0.547s
```

```
sys     0m0.016s
```

```
madhav@LAPTOP-RUM7KR1E: /mnt/c/
```

4. N=256

Execution Time: 5.590s

Meat Portion: 4.251s

(Meat Portion/Execution Time): 0.76

```
Time : 4.251851899999565
```

```
real    0m5.590s
```

```
user    0m4.281s
```

```
sys     0m0.078s
```

```
madhav@LAPTOP-RUM7KR1E: /mnt/c/
```

5. N=512

Execution Time: 39.384s

Meat Portion: 38.05s

(Meat Portion/Execution Time): 0.96

```
Time : 38.051534600000195
```

```
real    0m39.384s
```

```
user    0m37.813s
```

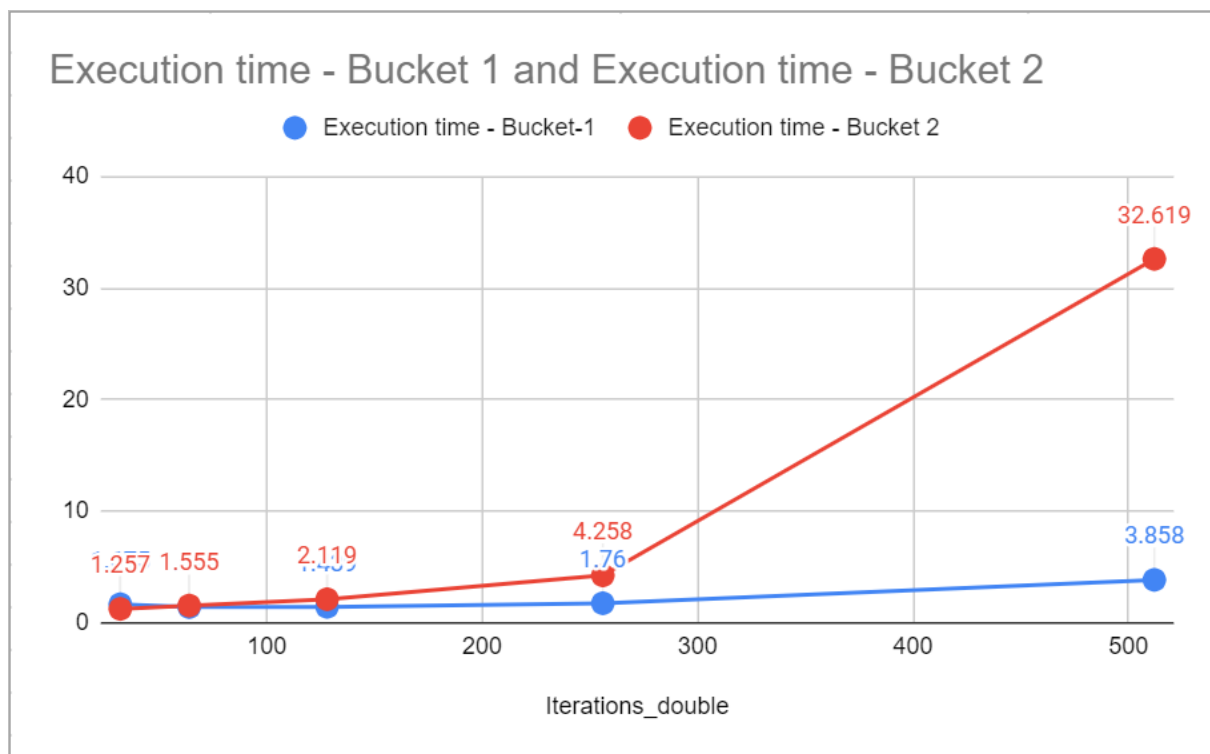
```
sys     0m0.125s
```

```
madhav@LAPTOP-RUM7KR1E: /mnt/c/
```

c)

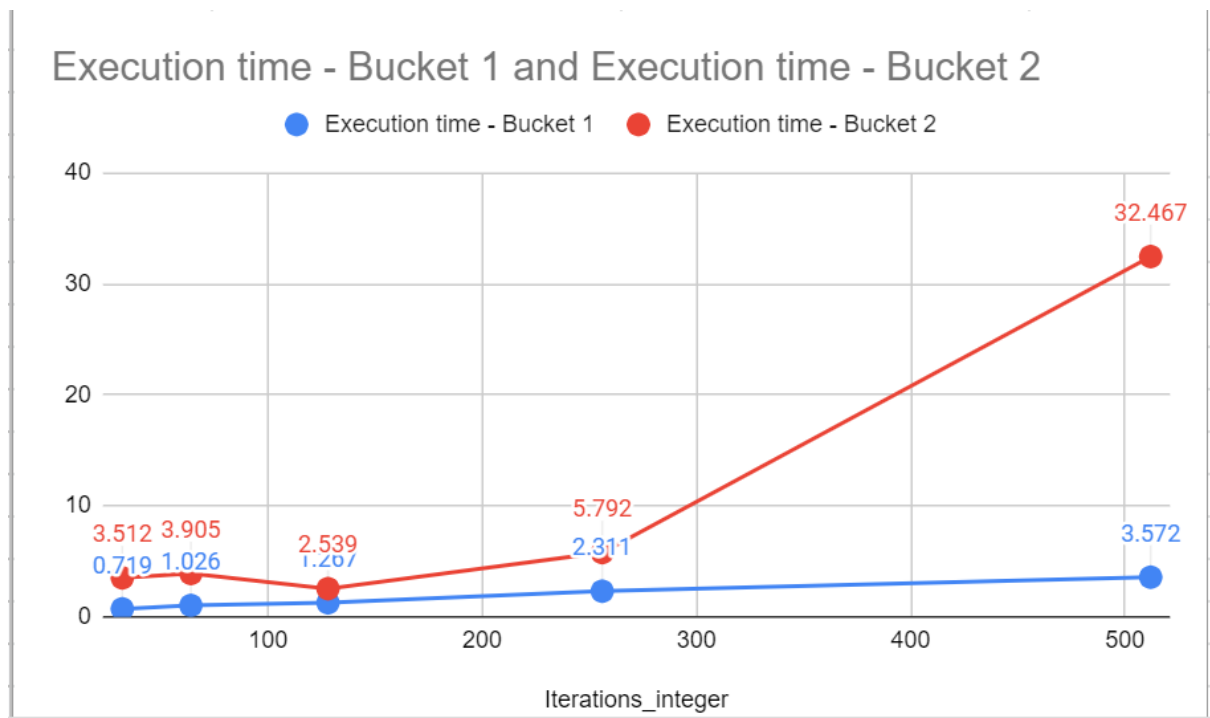
### Execution Time for Double of the Two programming languages

Iterations_double	Execution time - Bucket-1	Execution time - Bucket 2
32	1.675	1.257
64	1.413	1.555
128	1.439	2.119
256	1.76	4.258
512	3.858	32.619



### Execution Time for Integer of the two program languages

Iterations_integer	Execution time - Bucket 1	Execution time - Bucket 2
32	0.719	3.512
64	1.026	3.905
128	1.267	2.539
256	2.311	5.792
512	3.572	32.467





Meat Portion Time for Integer of the two program languages

Iterations_intege	Meat Portion - Bucket-1	Meat Portion - Bucket 2
32	0.015625	0.107
64	0.015625	0.056
128	0.048675	2.48
256	0.09375	4.25
512	0.84375	38.05

