Walchand College of Engineering, Sangli
Department of Computer Science and Engineering

Class: Final Year (Computer Science and Engineering)

Year: 2023-24 **Semester:** 1

Course: High Performance Computing Lab

Practical No. 2

Exam Seat No: 2020BTECS00033

Name: Prathamesh Santosh Raje

Title of practical: Study and implementation of basic OpenMP clauses

Implement following Programs using OpenMP with C:

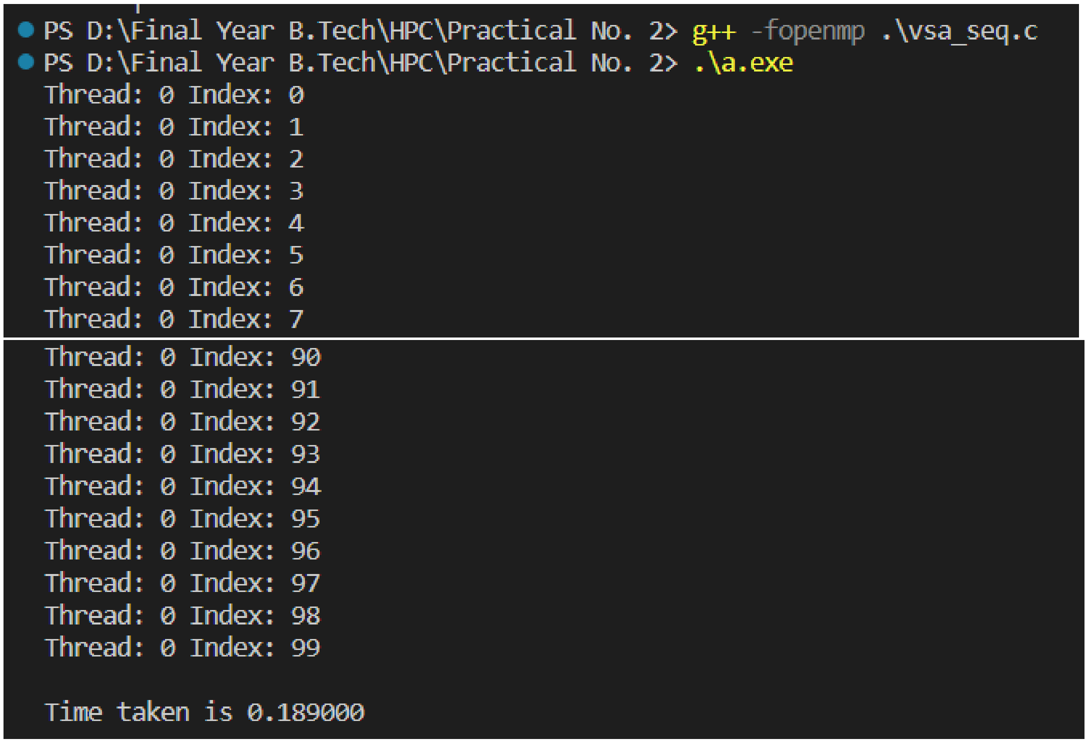
1. Vector Scalar Addition
2. Calculation of value of Pi
   Analyse the performance of your programs for different number of threads and Data size.

Problem Statement 1: Vector Scalar Addition
Screenshots:

Vector Scalar Addition Sequential Code:

```
#include <omp.h>
#include <stdio.h>
#include <pthread.h>

int main()
{
    int N = 100;
    int A[N];
    for(int i=0;i<N;i++)A[i] = i + 1;
    int S = 2000;

    double itime, ftime, exec_time;
    itime = omp_get_wtime();
    for (int i = 0; i < N; i++)
    {
        A[i] += S;
        printf("Thread: %d Index: %d\n", omp_get_thread_num(),i);
    }
    ftime = omp_get_wtime();
    exec_time = ftime - itime;

    printf("\nTime taken is %f\n", exec_time);
    printf("\n");
}
```

Vector Scalar Addition Sequential Output:



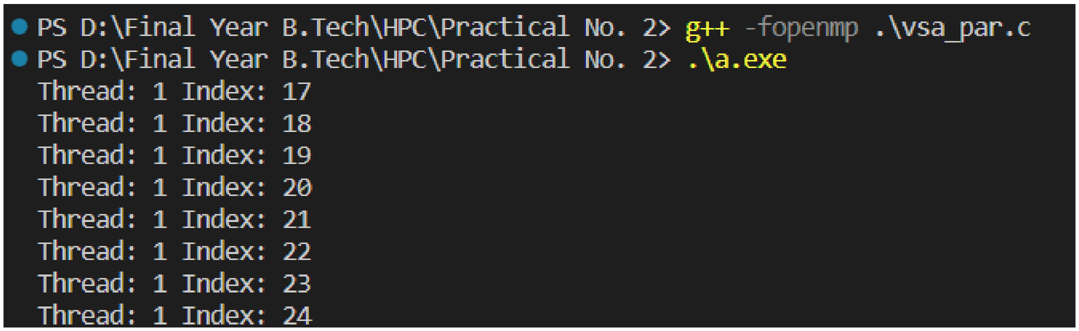
```
● PS D:\Final Year B.Tech\HPC\Practical No. 2> g++ -fopenmp .\vsa_seq.c
● PS D:\Final Year B.Tech\HPC\Practical No. 2> .\a.exe
  Thread: 0 Index: 0
  Thread: 0 Index: 1
  Thread: 0 Index: 2
  Thread: 0 Index: 3
  Thread: 0 Index: 4
  Thread: 0 Index: 5
  Thread: 0 Index: 6
  Thread: 0 Index: 7
```

```
  Thread: 0 Index: 90
  Thread: 0 Index: 91
  Thread: 0 Index: 92
  Thread: 0 Index: 93
  Thread: 0 Index: 94
  Thread: 0 Index: 95
  Thread: 0 Index: 96
  Thread: 0 Index: 97
  Thread: 0 Index: 98
  Thread: 0 Index: 99

  Time taken is 0.189000
```

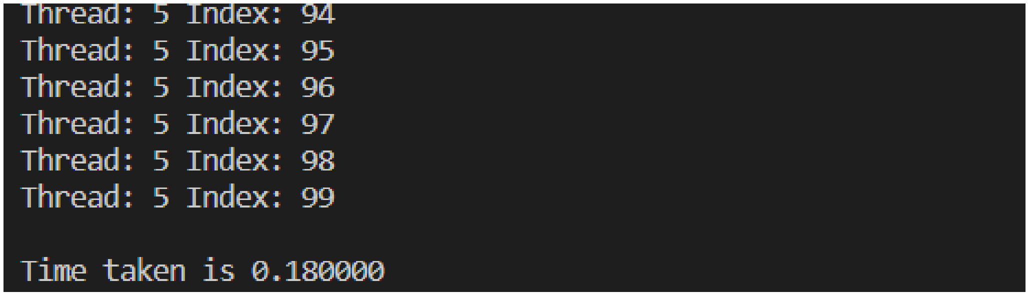
Vector Scalar Addition Parallel Code:

```
#include <omp.h>
#include <stdio.h>
#include <pthread.h>

int main()
{
    int N = 100;
    int A[N];
    for(int i=0;i<N;i++)A[i] = i + 1;
    int S = 212354454;

    omp_set_num_threads(6);
    double itime, ftime, exec_time;
    itime = omp_get_wtime();
    #pragma omp parallel
    for (int i = 0; i < N; i++)
    {
        A[i] += S;
        printf("Thread: %d Index: %d\n", omp_get_thread_num(),i);
    }
    ftime = omp_get_wtime();
    exec_time = ftime - itime;

    printf("\nTime taken is %f\n", exec_time);
}
```

Vector Scalar Addition Parallel Output:



```
PS D:\Final Year B.Tech\HPC\Practical No. 2> g++ -fopenmp .\vsa_par.c
PS D:\Final Year B.Tech\HPC\Practical No. 2> .\a.exe
Thread: 1 Index: 17
Thread: 1 Index: 18
Thread: 1 Index: 19
Thread: 1 Index: 20
Thread: 1 Index: 21
Thread: 1 Index: 22
Thread: 1 Index: 23
Thread: 1 Index: 24
```



```
Thread: 5 Index: 94
Thread: 5 Index: 95
Thread: 5 Index: 96
Thread: 5 Index: 97
Thread: 5 Index: 98
Thread: 5 Index: 99

Time taken is 0.180000
```

Information:

Execution time for sequential processing is: **0.189000**

Execution time for parallel processing is: **0.180000**

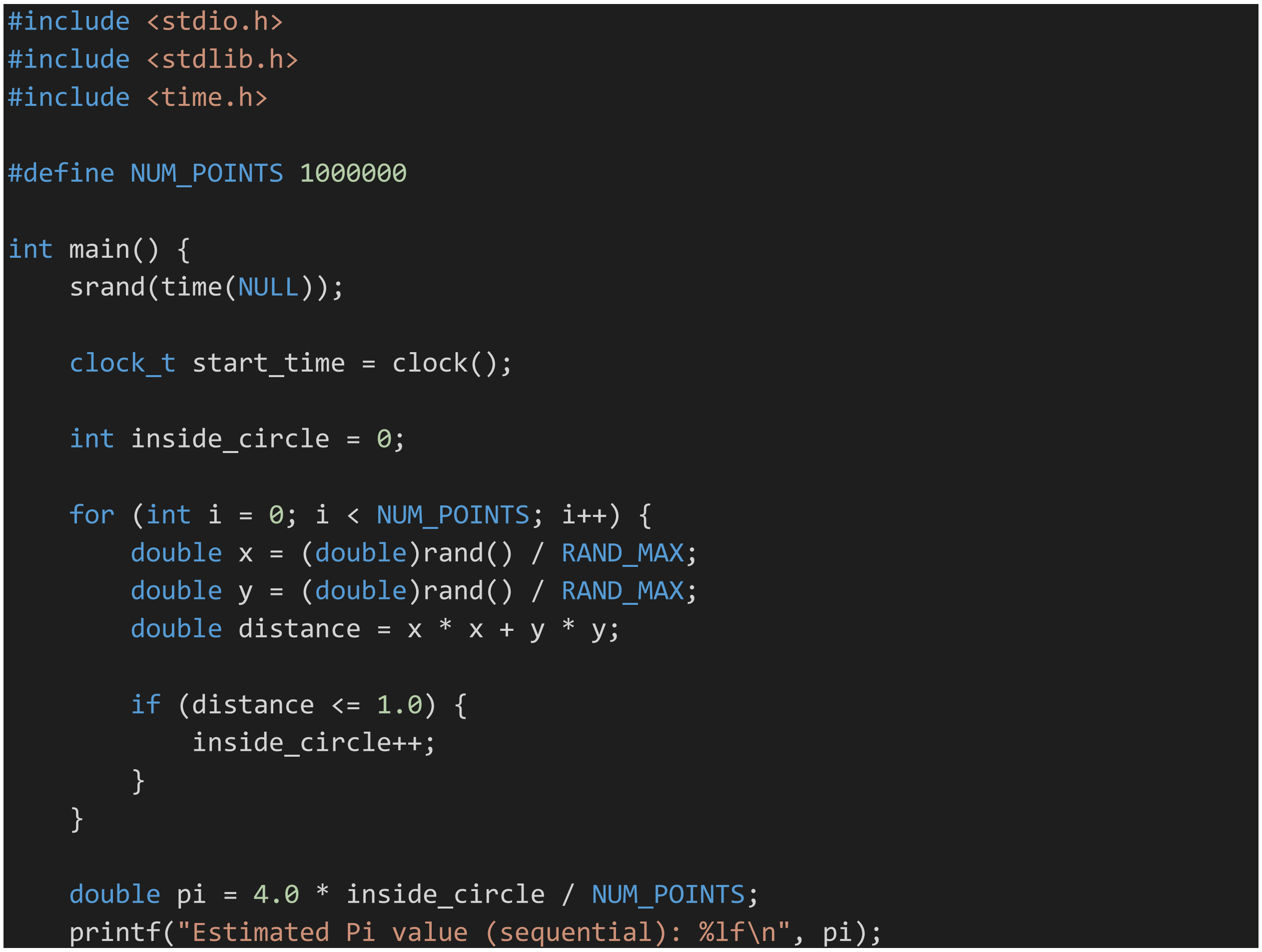
Analysis:

No. of Threads	Execution Time	
	Size = 100	Size = 1000
2	0.165000	1.105000
4	0.110000	1.100000
6	0.117000	1.088000
8	0.107000	1.133000

As the number of threads increasing, the performance is increased. Increasing the thread count beyond the number of CPU cores can potentially reduce execution time up to a point. Beyond that point, excessive threads may introduce overhead. Changing the thread count won't directly affect execution time since it's fixed at 6 threads. However, execution time can still vary depending on hardware and workload characteristics.

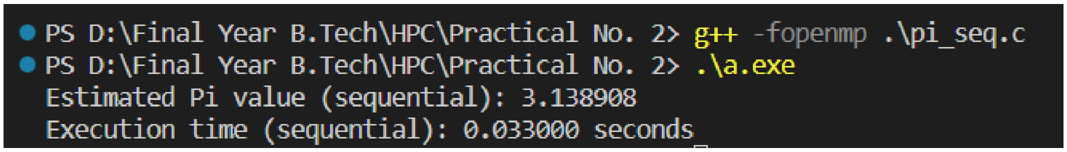
Problem Statement 2: Calculation of value of Pi
Screenshots:

Calculation of value of Pi Sequential Code:



```
#include <stdio.h>
#include <stdlib.h>
#include <time.h>

#define NUM_POINTS 1000000

int main() {
    srand(time(NULL));

    clock_t start_time = clock();

    int inside_circle = 0;

    for (int i = 0; i < NUM_POINTS; i++) {
        double x = (double)rand() / RAND_MAX;
        double y = (double)rand() / RAND_MAX;
        double distance = x * x + y * y;

        if (distance <= 1.0) {
            inside_circle++;
        }
    }

    double pi = 4.0 * inside_circle / NUM_POINTS;
    printf("Estimated Pi value (sequential): %lf\n", pi);
    clock_t end_time = clock();
    double execution_time = (double)(end_time - start_time) / CLOCKS_PER_SEC;
    printf("Execution time (sequential): %lf seconds\n", execution_time);

    return 0;
}
```

Calculation of value of Pi Sequential Output:

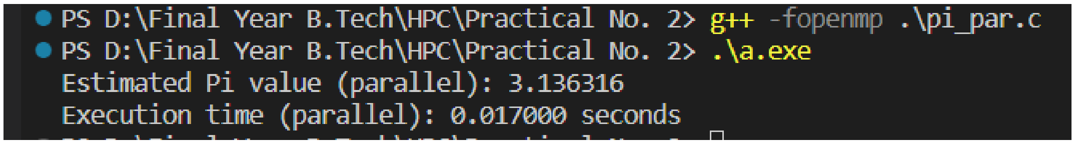


```
PS D:\Final Year B.Tech\HPC\Practical No. 2> g++ -fopenmp .\pi_seq.c
PS D:\Final Year B.Tech\HPC\Practical No. 2> .\a.exe
Estimated Pi value (sequential): 3.138908
Execution time (sequential): 0.033000 seconds
```

Calculation of value of Pi Parallel Code:

```
#include <stdio.h>
#include <stdlib.h>
#include <time.h>
#include <omp.h>

#define NUM_POINTS 1000000

int main() {
    srand(time(NULL));

    clock_t start_time = clock();

    int inside_circle = 0;

    #pragma omp parallel for reduction(+:inside_circle)
    for (int i = 0; i < NUM_POINTS; i++) {
        double x = (double)rand() / RAND_MAX;
        double y = (double)rand() / RAND_MAX;
        double distance = x * x + y * y;

        if (distance <= 1.0) {
            inside_circle++;
        }
    }

    double pi = 4.0 * inside_circle / NUM_POINTS;
    printf("Estimated Pi value (parallel): %lf\n", pi);

    clock_t end_time = clock();
    double execution_time = (double)(end_time - start_time) /
CLOCKS_PER_SEC;
    printf("Execution time (parallel): %lf seconds\n", execution_time);

    return 0;
}
```

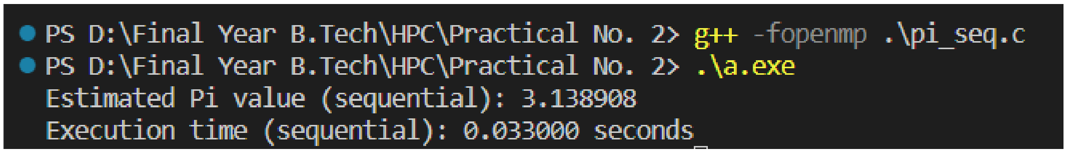
Calculation of value of Pi Parallel Output:



```
PS D:\Final Year B.Tech\HPC\Practical No. 2> g++ -fopenmp .\pi_par.c
PS D:\Final Year B.Tech\HPC\Practical No. 2> .\a.exe
Estimated Pi value (parallel): 3.136316
Execution time (parallel): 0.017000 seconds
```

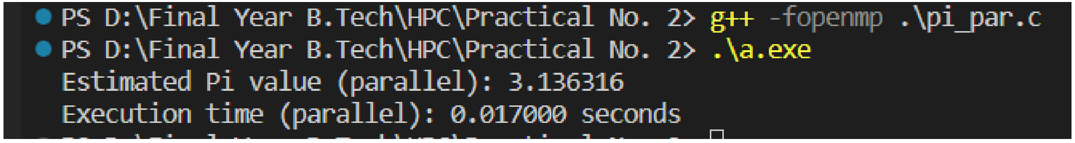
Information:

Execution time for sequential processing is:



```
PS D:\Final Year B.Tech\HPC\Practical No. 2> g++ -fopenmp .\pi_seq.c
PS D:\Final Year B.Tech\HPC\Practical No. 2> .\a.exe
Estimated Pi value (sequential): 3.138908
Execution time (sequential): 0.033000 seconds
```

Execution time for parallel processing is:



```
PS D:\Final Year B.Tech\HPC\Practical No. 2> g++ -fopenmp .\pi_par.c
PS D:\Final Year B.Tech\HPC\Practical No. 2> .\a.exe
Estimated Pi value (parallel): 3.136316
Execution time (parallel): 0.017000 seconds
```

Analysis:

No. of Threads	**Execution Time**	
	Num_points = 1000000	**Num_points = 100000000**
2	**0.022000**	**0.658000**
4	**0.014000**	**0.924000**
6	**0.021000**	**0.659000**
8	**0.013000**	**0.614000**

As the number of threads increasing, the performance is increased. Increasing the thread count beyond the number of CPU cores can potentially reduce execution time up to a point. Beyond that point, excessive threads may introduce overhead. Changing the thread count won't directly affect execution time since it's fixed at 6 threads. However, execution time can still vary depending on hardware and workload characteristics.

Github Link: