CS2023 – Data structures and algorithms

Lab 03 report

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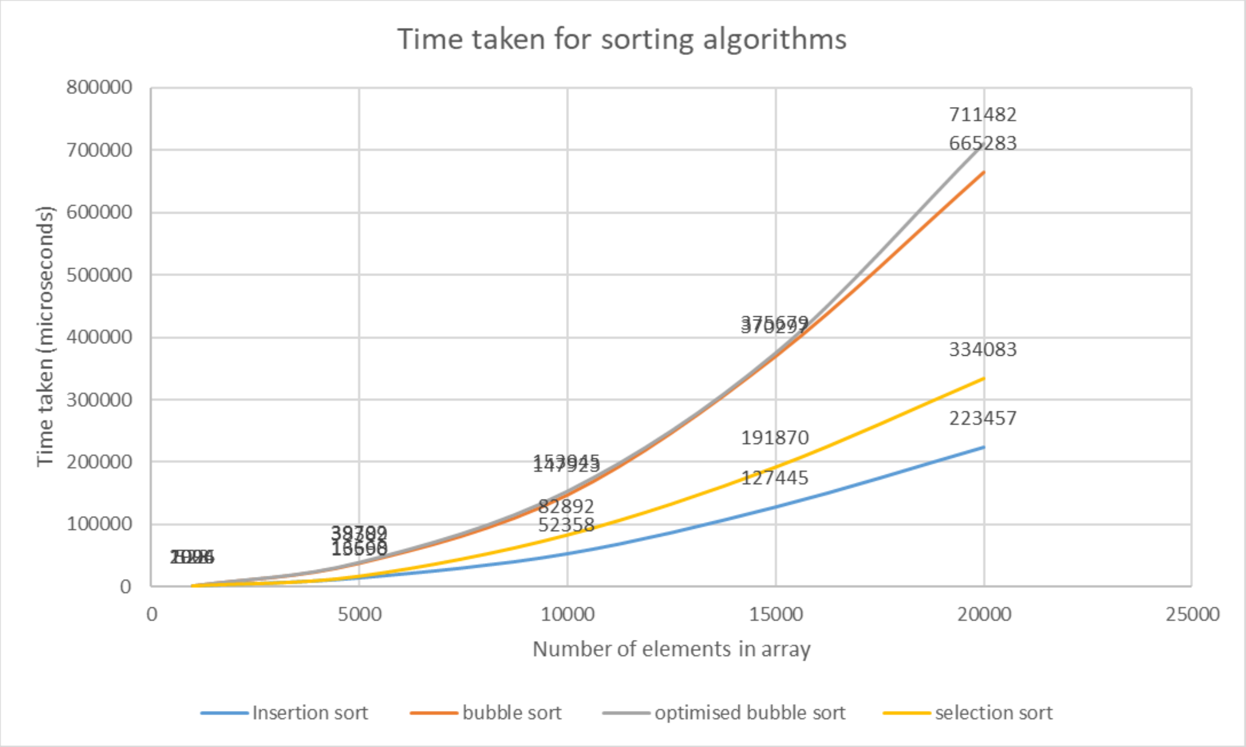
1. Output

Sorting Type	Elements in array	Time taken (microseconds)
Insertion Sort	1000	528
	5000	13590
	10000	52358
	150000	127445
	200000	223457
Bubble Sort	1000	1994
	5000	38389
	10000	147923
	150000	370297
	200000	665283
Optimised Bubble Sort	1000	2026
	5000	39702
	10000	153945
	150000	375679
	200000	711482
Selection Sort	1000	1006
	5000	16668
	10000	82892
	150000	191870
	200000	334083

2. Plot



3. Conclusion

Bubble sort and optimized bubble sort algorithms are simple and easy to understand but the time complexities are higher than other sorting algorithms.

The optimized bubble sort algorithm is a small upgrade to the bubble sort algorithm, where it can find whether the array is already sorted or not and execute or stop execution according to the state of an array.

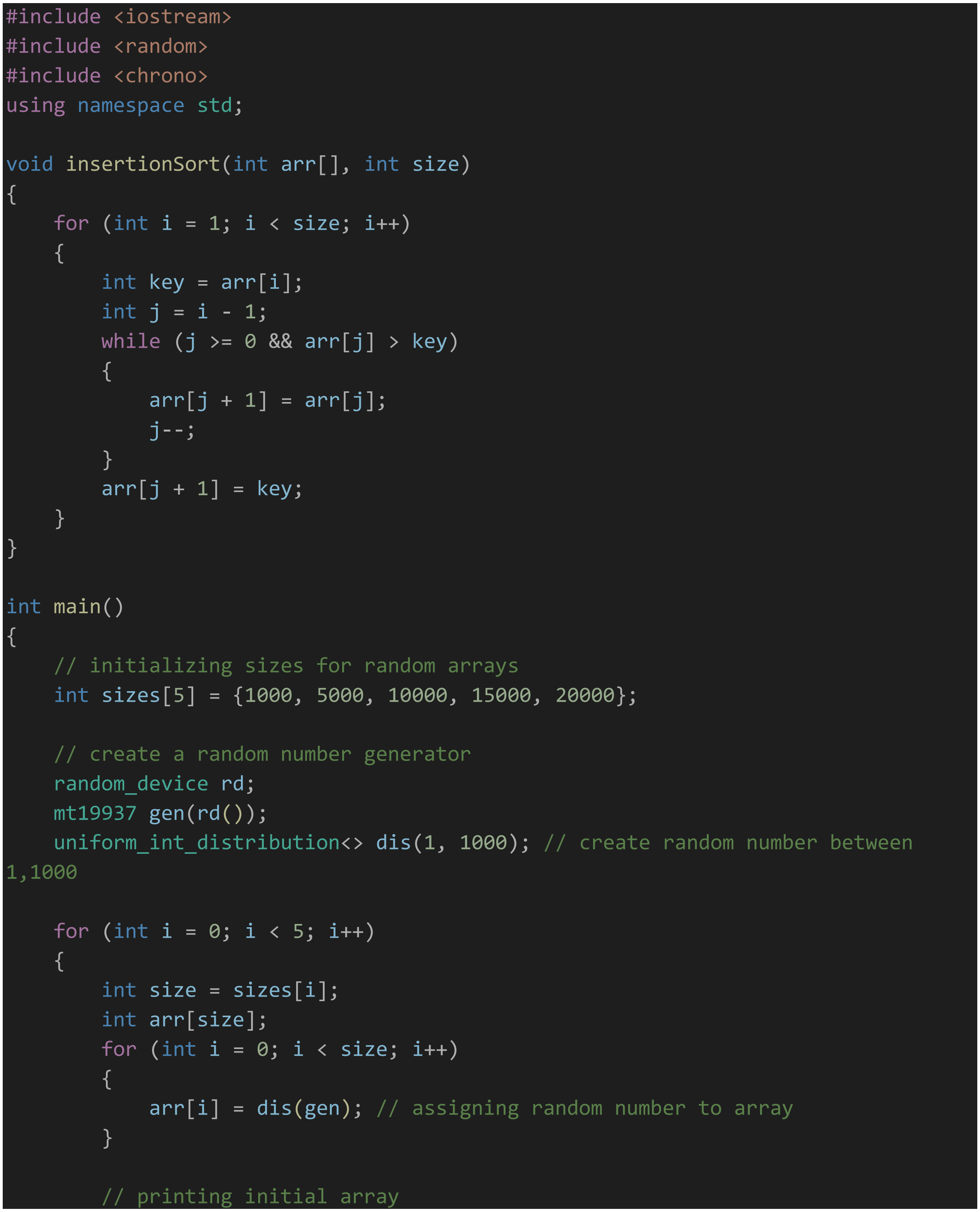
But in the worst-case scenarios, both of these are the same.

Selection sort also has the same time complexity as bubble sort algorithms, but it can deal with larger arrays better than bubble sort algorithms, as you can see in the plot when the array size is getting larger, the time taken for selection sort is becoming lower than bubble sort.

above all algorithms, insertion sort is far better. but it can perform well in small arrays and best-case scenarios. it also has the same time complexity as other algorithms

3. Appendix (source codes)

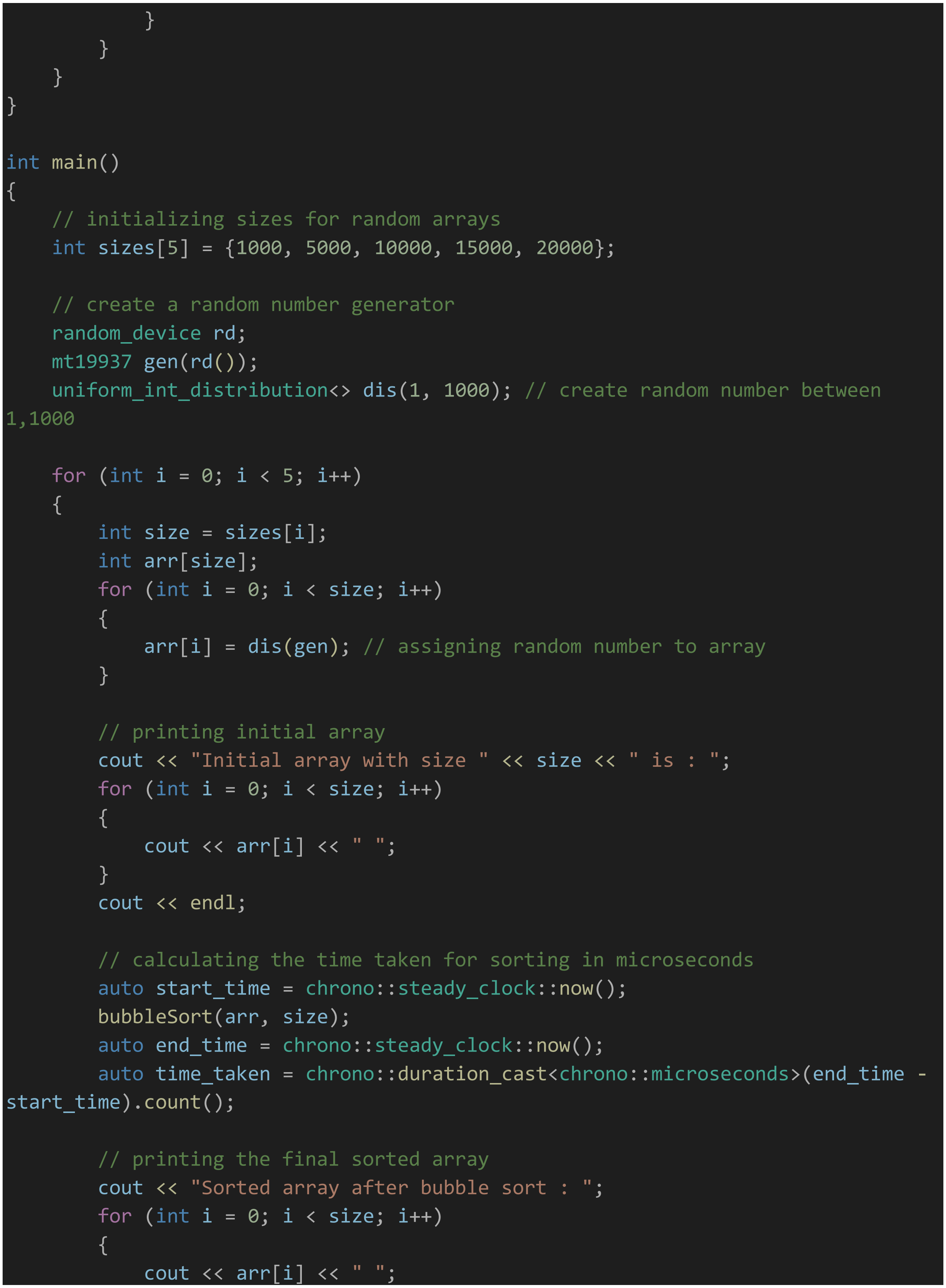
a) insertion sort



```
#include <iostream>
#include <random>
#include <chrono>
using namespace std;

void insertionSort(int arr[], int size)
{
    for (int i = 1; i < size; i++)
    {
        int key = arr[i];
        int j = i - 1;
        while (j >= 0 && arr[j] > key)
        {
            arr[j + 1] = arr[j];
            j--;
        }
        arr[j + 1] = key;
    }
}

int main()
{
    // initializing sizes for random arrays
    int sizes[5] = {1000, 5000, 10000, 15000, 20000};

    // create a random number generator
    random_device rd;
    mt19937 gen(rd());
    uniform_int_distribution<> dis(1, 1000); // create random number between
1,1000

    for (int i = 0; i < 5; i++)
    {
        int size = sizes[i];
        int arr[size];
        for (int i = 0; i < size; i++)
        {
            arr[i] = dis(gen); // assigning random number to array
        }

        // printing initial array
        cout << "Initial array with size " << size << " is : ";
        for (int i = 0; i < size; i++)
        {
            cout << arr[i] << " ";
        }
        cout << endl;

        // calculating the time taken for sorting in microseconds
        auto start_time = chrono::steady_clock::now();
        insertionSort(arr, size);
        auto end_time = chrono::steady_clock::now();
        auto time_taken = chrono::duration_cast<chrono::microseconds>(end_time - 
start_time).count();

        // printing the final sorted array
        cout << "Sorted array after insertion sort : ";
        for (int i = 0; i < size; i++)
        {
            cout << arr[i] << " ";
        }
        cout << endl;

        cout << "Time taken : " << time_taken << " microseconds" << endl;
    }
}
```

b) bubble sort

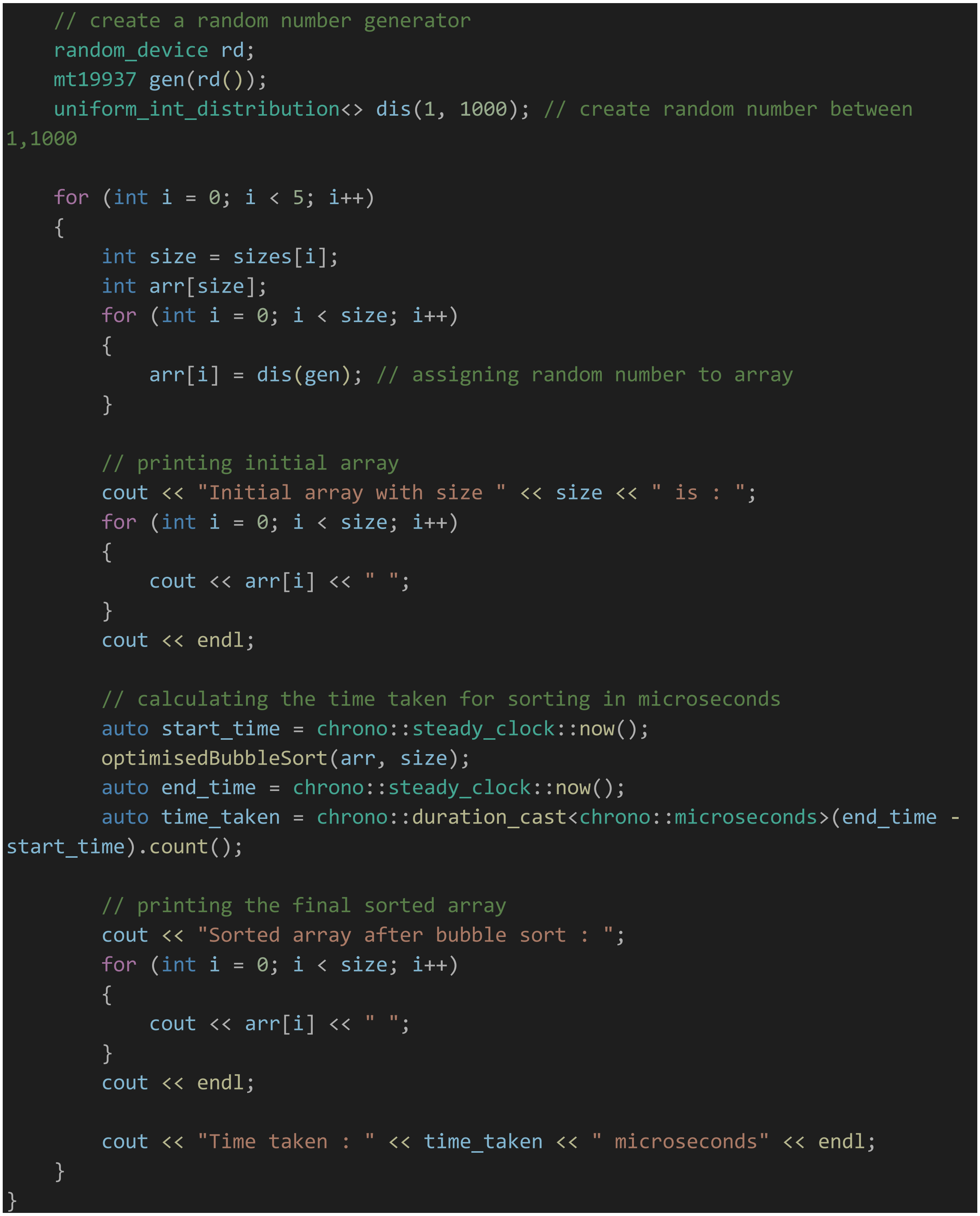
```
#include <iostream>
#include <random>
#include <chrono>
using namespace std;

void bubbleSort(int arr[], int size)
{
    for (int i = 0; i < size - 1; i++)
    {
        for (int j = 0; j < size - i - 1; j++)
        {
            if (arr[j] > arr[j + 1])
            {
                // swap the elements
                int temp = arr[j];
                arr[j] = arr[j + 1];
                arr[j + 1] = temp;
```



```
            }
        }
    }
}

int main()
{
    // initializing sizes for random arrays
    int sizes[5] = {1000, 5000, 10000, 15000, 20000};

    // create a random number generator
    random_device rd;
    mt19937 gen(rd());
    uniform_int_distribution<> dis(1, 1000); // create random number between
1,1000

    for (int i = 0; i < 5; i++)
    {
        int size = sizes[i];
        int arr[size];
        for (int i = 0; i < size; i++)
        {
            arr[i] = dis(gen); // assigning random number to array
        }

        // printing initial array
        cout << "Initial array with size " << size << " is : ";
        for (int i = 0; i < size; i++)
        {
            cout << arr[i] << " ";
        }
        cout << endl;

        // calculating the time taken for sorting in microseconds
        auto start_time = chrono::steady_clock::now();
        bubbleSort(arr, size);
        auto end_time = chrono::steady_clock::now();
        auto time_taken = chrono::duration_cast<chrono::microseconds>(end_time -
start_time).count();

        // printing the final sorted array
        cout << "Sorted array after bubble sort : ";
        for (int i = 0; i < size; i++)
        {
            cout << arr[i] << " ";
        }
        cout << endl;

        cout << "Time taken : " << time_taken << " microseconds" << endl;
    }
}
```

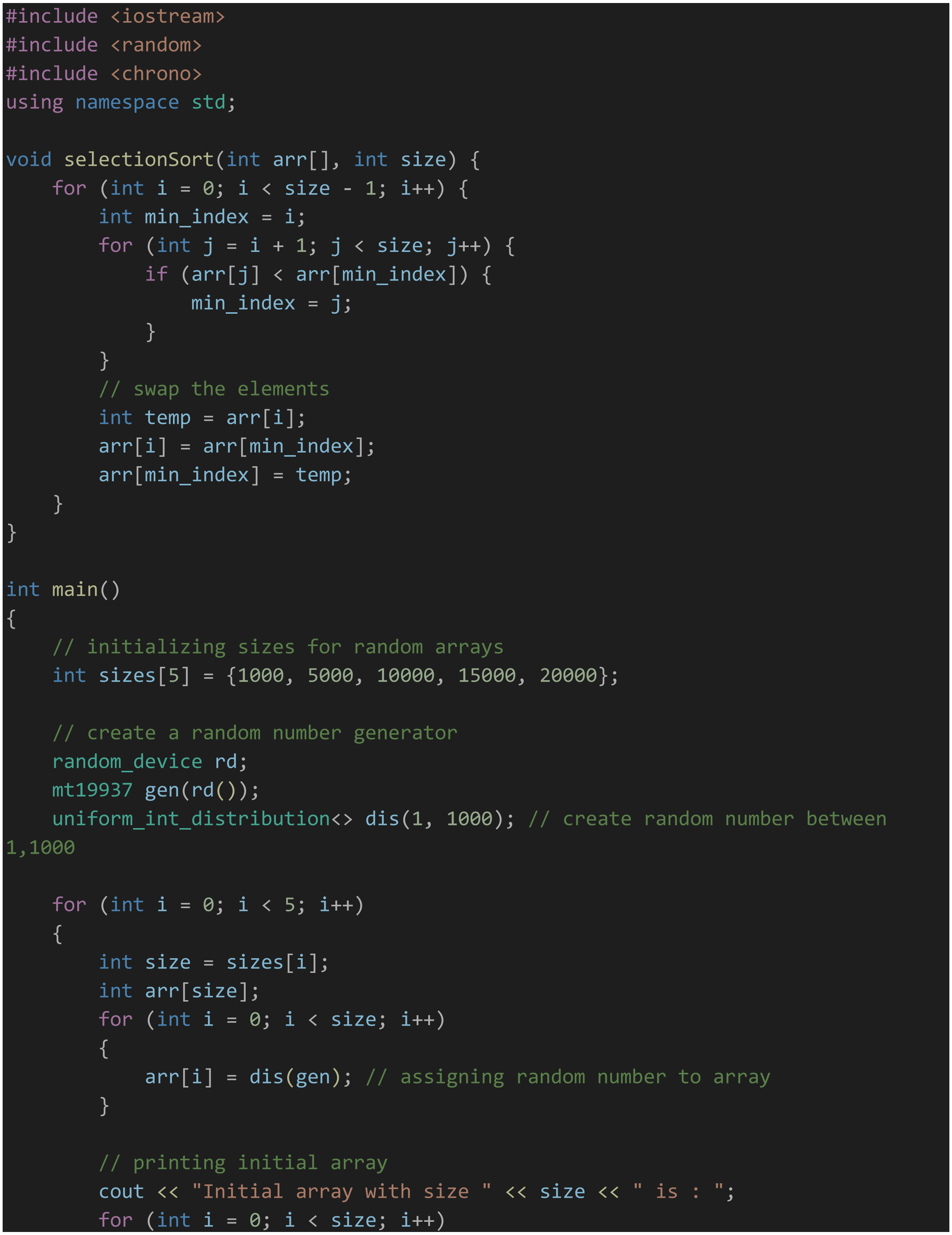
c) optimized bubble sort

```
#include <iostream>
#include <random>
#include <chrono>
using namespace std;

void optimisedBubbleSort(int arr[], int size)
{
    bool swapped; // flag to check if any swaps were made in the previous
iteration
    for (int i = 0; i < size - 1; i++)
    {
        swapped = false;
        for (int j = 0; j < size - i - 1; j++)
        {
            if (arr[j] > arr[j + 1])
            {
                // swap the elements
                int temp = arr[j];
                arr[j] = arr[j + 1];
                arr[j + 1] = temp;
                swapped = true;
            }
        }
        // if no swaps were made in this iteration, the array is already sorted
        if (!swapped)
        {
            break;
        }
    }
}

int main()
{
    // initializing sizes for random arrays
    int sizes[5] = {1000, 5000, 10000, 15000, 20000};
```

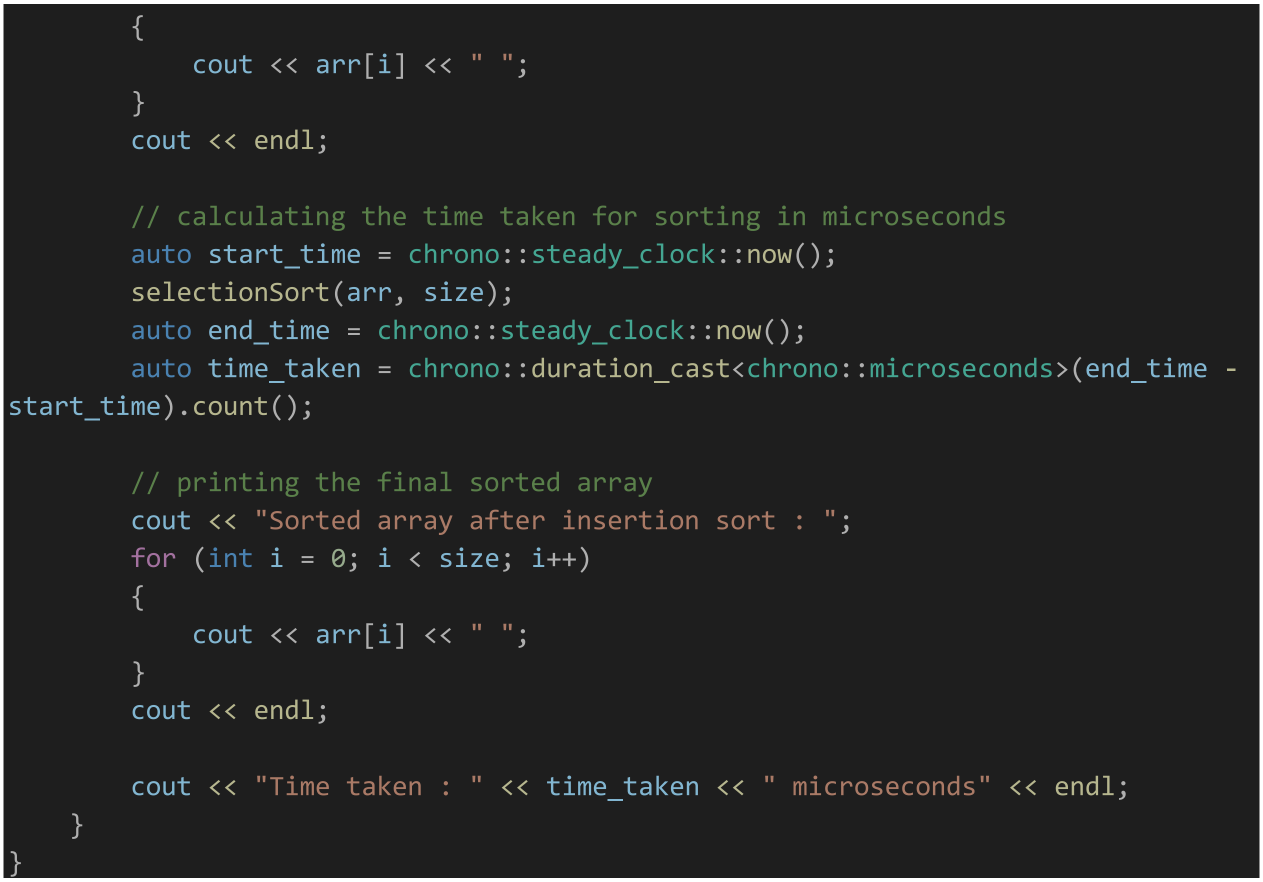


```
    // create a random number generator
    random_device rd;
    mt19937 gen(rd());
    uniform_int_distribution<> dis(1, 1000); // create random number between
1,1000

    for (int i = 0; i < 5; i++)
    {
        int size = sizes[i];
        int arr[size];
        for (int i = 0; i < size; i++)
        {
            arr[i] = dis(gen); // assigning random number to array
        }

        // printing initial array
        cout << "Initial array with size " << size << " is : ";
        for (int i = 0; i < size; i++)
        {
            cout << arr[i] << " ";
        }
        cout << endl;

        // calculating the time taken for sorting in microseconds
        auto start_time = chrono::steady_clock::now();
        optimisedBubbleSort(arr, size);
        auto end_time = chrono::steady_clock::now();
        auto time_taken = chrono::duration_cast<chrono::microseconds>(end_time -
start_time).count();

        // printing the final sorted array
        cout << "Sorted array after bubble sort : ";
        for (int i = 0; i < size; i++)
        {
            cout << arr[i] << " ";
        }
        cout << endl;

        cout << "Time taken : " << time_taken << " microseconds" << endl;
    }
}
```

d) selection sort



```
#include <iostream>
#include <random>
#include <chrono>
using namespace std;

void selectionSort(int arr[], int size) {
    for (int i = 0; i < size - 1; i++) {
        int min_index = i;
        for (int j = i + 1; j < size; j++) {
            if (arr[j] < arr[min_index]) {
                min_index = j;
            }
        }
        // swap the elements
        int temp = arr[i];
        arr[i] = arr[min_index];
        arr[min_index] = temp;
    }
}

int main()
{
    // initializing sizes for random arrays
    int sizes[5] = {1000, 5000, 10000, 15000, 20000};

    // create a random number generator
    random_device rd;
    mt19937 gen(rd());
    uniform_int_distribution<> dis(1, 1000); // create random number between
1,1000

    for (int i = 0; i < 5; i++)
    {
        int size = sizes[i];
        int arr[size];
        for (int i = 0; i < size; i++)
        {
            arr[i] = dis(gen); // assigning random number to array
        }

        // printing initial array
        cout << "Initial array with size " << size << " is : ";
        for (int i = 0; i < size; i++)
```



```
        {
            cout << arr[i] << " ";
        }
        cout << endl;

        // calculating the time taken for sorting in microseconds
        auto start_time = chrono::steady_clock::now();
        selectionSort(arr, size);
        auto end_time = chrono::steady_clock::now();
        auto time_taken = chrono::duration_cast<chrono::microseconds>(end_time -
start_time).count();

        // printing the final sorted array
        cout << "Sorted array after insertion sort : ";
        for (int i = 0; i < size; i++)
        {
            cout << arr[i] << " ";
        }
        cout << endl;

        cout << "Time taken : " << time_taken << " microseconds" << endl;
    }
}
```