Homework #1

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1 and 2.

Below is the C++ source code of this homework

```
#include <iostream>
#include <ctime>
#include <cstdlib>
#include <cstdio>
using namespace std;

// O(length) time overall for this insert function
int *insert(int *array, int length, int index, int value) {

    int* newArray = NULL;                    // O(1) time

    // input array is empty, return a new array with length 1 and the target value
    if (length == 0) {                       // O(1) time overall for if
        newArray = new int[1];               // O(1) time
        newArray[0] = value;                 // O(1) time
        return newArray;                     // O(1) time
    }

    newArray = new int[length + 1];          // O(1) time

    // copy array[0, index) to newArray[0, index)
    for (int i = 0; i < index; ++i) {        // O(index) time overall
        newArray[i] = array[i];              // O(1) time
```

```
    }

    newArray[index] = value;                  // O(1) time

    // copy array[index, length) to newArray[index + 1, length + 1)
    for (int i = index; i < length; ++i) {    // O(length - index) time overall
        newArray[i + 1] = array[i];           // O(1) time
    }

    delete [] array; // free the memory of the old array, O(1) time
    return newArray;                          // O(1) time
}

int main() {

    const int INSERTS_PER_READING = 1000;

    // start with an empty array
    int* array = NULL;
    int length = 0;

    // print the header
    printf("%15s %20s\n", "Array length", "Seconds per insert");

    // take 60 readings
    for (int i = 0; i < 60; ++i) {
        clock_t startTime = clock();
```

```
        // Each reading will be taken after INSERTS_PER_READING inserts
        for (int j = 0; j < INSERTS_PER_READING; ++j) {
            int index = rand() % (length + 1); // random index in [0, length]
            int value = rand(); // random integer value
            array = insert(array, length, index, value);
            length++;
        }

        clock_t stopTime = clock();
        double timePerInsert = static_cast<double>(stopTime - startTime)
            / CLOCKS_PER_SEC / INSERTS_PER_READING;

        // Output reading in tabular format
        printf("%15d %20.8f\n", (i + 1) * INSERTS_PER_READING, timePerInsert);
    }

    // free the old array
    delete [] array;
    return 0;
}
```

And I compile the code with g++ using the following command:
g++ hw1.cpp -o hw1.exe

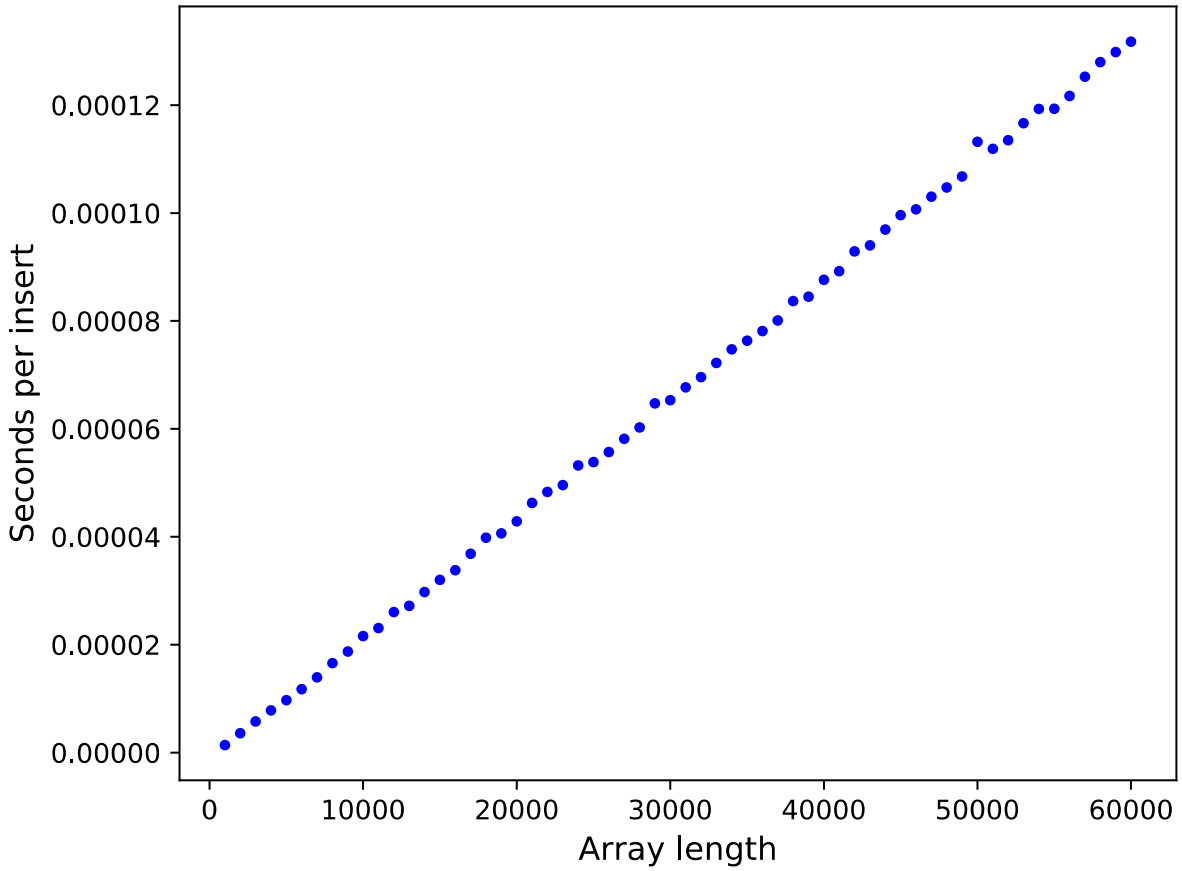
The output of the program is shown as follows.

```
   Array length   Seconds per insert
           1000           0.00000138
           2000           0.00000358
           3000           0.00000576
```

4000	0.00000781
5000	0.00000972
6000	0.00001175
7000	0.00001393
8000	0.00001659
9000	0.00001873
10000	0.00002159
11000	0.00002306
12000	0.00002603
13000	0.00002720
14000	0.00002976
15000	0.00003200
16000	0.00003380
17000	0.00003685
18000	0.00003983
19000	0.00004063
20000	0.00004286
21000	0.00004626
22000	0.00004832
23000	0.00004958
24000	0.00005323
25000	0.00005383
26000	0.00005569
27000	0.00005815
28000	0.00006025
29000	0.00006473
30000	0.00006531
31000	0.00006769
32000	0.00006959
33000	0.00007223
34000	0.00007473
35000	0.00007634
36000	0.00007813
37000	0.00008010
38000	0.00008367
39000	0.00008449
40000	0.00008763
41000	0.00008921
42000	0.00009288
43000	0.00009401
44000	0.00009695
45000	0.00009960
46000	0.00010069
47000	0.00010303
48000	0.00010474
49000	0.00010677
50000	0.00011321

```
51000           0.00011189
52000           0.00011349
53000           0.00011664
54000           0.00011930
55000           0.00011933
56000           0.00012171
57000           0.00012526
58000           0.00012798
59000           0.00012982
60000           0.00013176
```

3. Using the profiling data from main, I plotted “Seconds per insert” (Y-axis) vs. “Array length” (X-axis).



4. A line-by-line Big-O analysis is shown by the inline comments in the source code, as can be seen from page 1. The overall time complexity of this insert function is O(n), where n is the length of the array. In this function, copying data from input array to the new array contributes most heavily to the overall time complexity.

5. From the plot, the seconds-per-insert scales linearly as the array length grows. This matches the Big-O analysis of O(n). In this respect, the performance roughly stays the same.

6. I followed the best practices when doing this homework.