**Lab Description:**

\*\*In README File

\*Not on lab write up

**Question C. Graph:**

**Main.cpp:**

#include <iostream>

#include <stdio.h>

#include <time.h>

#include <chrono>

int count = 0;

void bubbleSort(int\*, int, bool); // sort the function using bubble sort algorithm

void selectionSort(int\*, int, bool); // sort the funciton using selection sort algorithm

void insertionSort(int\*, int, bool); // sort the function using insertion sort algorithm

int\* makeArray(int); // creates a dynamic array of integers

int\* makeArray2(int); // creates a dynamic array of integers in backwards order

void swap(int&, int&); // swaps two integers that are passed by reference

bool isSorted(int\*, int, bool); // tests to see if the array is sorted in the correct order

void timeSort(void (\*sort)(int\*, int, bool), int\*, int, bool); // generic size array timing array

int main() {

bool ascending = true; // boolean to see which way the array is to be sorted

srand(time(NULL)); // seed the random number generator

int sizesLen = 13;

int sizes[] = {10, 20, 50, 500, 700, 1000, 5000, 7500, 12000, 25000, 50000, 60000, 100000}; // Amount of integers test cases

std::cout << "====================================" << std::endl;

std::cout << "Sorting in Ascending order!" << std::endl;

std::cout << "Bubble Sort: " << std::endl;

for (int i = 0; i < sizesLen; i++) { // Bubble sort ascending tests

int \*arr = makeArray(sizes[i]);

int len = sizes[i];

timeSort(bubbleSort, arr, len, ascending);

}

std::cout << "====================================" << std::endl;

std::cout << "Selection Sort: " << std::endl;

for (int i = 0; i < sizesLen; i++) { // Selection sort ascending tests

int \*arr = makeArray(sizes[i]);

int len = sizes[i];

timeSort(selectionSort, arr, len, ascending);

}

std::cout << "====================================" << std::endl;

std::cout << "Insertion Sort: " << std::endl;

for (int i = 0; i < sizesLen; i++) { // Insertion sort ascending tests

int \*arr = makeArray(sizes[i]);

int len = sizes[i];

timeSort(insertionSort, arr, len, ascending);

}

std::cout << "====================================" << std::endl;

std::cout << "Sorting in Descending order!" << std::endl;

std::cout << "Bubble Sort: " << std::endl;

for (int i = 0; i < sizesLen; i++) { // Bubble sort descending tests

int \*arr = makeArray(sizes[i]);

int len = sizes[i];

timeSort(bubbleSort, arr, len, ascending);

}

std::cout << "====================================" << std::endl;

std::cout << "Selection Sort: " << std::endl;

for (int i = 0; i < sizesLen; i++) { // Selection sort descending tests

int \*arr = makeArray(sizes[i]);

int len = sizes[i];

timeSort(selectionSort, arr, len, ascending);

}

std::cout << "====================================" << std::endl;

std::cout << "Insertion Sort: " << std::endl;

for (int i = 0; i < sizesLen; i++) { // Insertion sort descending tests

int \*arr = makeArray(sizes[i]);

int len = sizes[i];

timeSort(insertionSort, arr, len, ascending);

}

std::cout << "====================================" << std::endl;

ascending = true;

std::cout << "Sorting Worst Case scenario!" << std::endl;

std::cout << "Bubble Sort: " << std::endl;

for (int i = 0; i < sizesLen - 3; i++) {

int \*arr = makeArray2(sizes[i]);

int len = sizes[i];

timeSort(bubbleSort, arr, len, ascending);

}

std::cout << "====================================" << std::endl;

std::cout << "Selection Sort: " << std::endl;

for (int i = 0; i < sizesLen / 2; i++) {

int \*arr = makeArray2(sizes[i]);

int len = sizes[i];

timeSort(selectionSort, arr, len, ascending);

}

std::cout << "====================================" << std::endl;

std::cout << "Insertion Sort: " << std::endl;

for (int i = 0; i < sizesLen / 2; i++) {

int \*arr = makeArray2(sizes[i]);

int len = sizes[i];

timeSort(insertionSort, arr, len, ascending);

}

std::cout << "====================================" << std::endl;

return 0;

}

/\*

\* timeSort Function:

\* Calculate the time it takes for specific sorting algorithms to run on and completely sorted

\*/

void timeSort(void (\*sort)(int\*, int, bool), int\* a, int len, bool isAsc) {

auto start = std::chrono::system\_clock::now();

sort(a, len, isAsc);

auto end = std::chrono::system\_clock::now();

std::chrono::duration<double> elapsed\_seconds = end - start;

std::time\_t end\_time = std::chrono::system\_clock::to\_time\_t(end);

std::cout << "Finished at " << std::ctime(&end\_time) << "Elapsed time: " << elapsed\_seconds.count() << "s\n";

std::cout << "Amount of swaps " << count << std::endl;

if (isSorted(a, len, isAsc)) {

std::cout << "Sorted in correct order!" << std::endl;

} else {

std::cout << "Not sorted correctly!" << std::endl;

}

count = 0;

delete [] a;

}

/\*

\* makeArray Function:

\* Takes an int that is the length of an array and then dynamically creates that array and returns

\* a pointer to that array

\*/

int\* makeArray(int len) {

int \*rtn = new int[len];

for (int i = 0; i < len; i++) {

rtn[i] = 1 + rand() % 100; // from 1 to 100

}

return rtn;

}

/\*

\* makeArray2 Function:

\* Takes an int that is the length of an array and then dynamically creates that array

\* and returns a pointer to that array \*\*Used for specifically creating a worse case array

\*/

int\* makeArray2(int len) {

int \*rtn = new int[len];

for (int i = len - 1, j = 0; j < len; j++, i--) {

rtn[j] = i;

}

return rtn;

}

/\*

\* isSorted Function:

\* Takes a dynamic array, a lenth of that array, and whether the array is supposed to be sorted

\* in ascending or descending order and tahtn determines if the array is sorted correctly

\*/

bool isSorted(int\* arr, int length, bool ascending) {

if (ascending) {

for (int i = 0; i < (length - 1); i++) {

if (arr[i] > arr[i + 1]) {

return false;

}

}

return true;

} else {

for (int i = 0; i < (length - 1); i++) {

if (arr[i] < arr[i + 1]) {

return false;

}

}

return true;

}

}

/\*

\* swap Function:

\* Takes two array elements by reference and swaps them

\*/

void swap(int& prev, int& next) {

int temp = prev;

prev = next;

next = temp;

count++; // remember to make it 0 after each test

}

/\*

\* bubbleSort Function:

\* Takes a dynamic array, the length of the array, and whether the array is to be sorted in ascending

\* or descending and then sorts the array

\*/

void bubbleSort(int\* arr, int length, bool ascending) {

bool didSwap = true;

while (didSwap) {

didSwap = false;

for (int i = 0; i < (length - 1); i++) {

if (ascending) {

if (arr[i] > arr[i + 1]) {

swap(arr[i], arr[i + 1]);

didSwap = true;

}

} else {

if (arr[i] < arr[i + 1]) {

swap(arr[i], arr[i + 1]);

didSwap = true;

}

}

}

}

}

/\*

\* \* selectionSort Function:

\* \* Takes a dynamic array, the length of the array, and whether the array is to be sorted in ascending

\* \* or descending order and then sorts the array

\* \*/

void selectionSort(int\* arr, int length, bool ascending) {

int min;

for (int i = 0; i < length - 1; i++) {

min = i;

for (int j = i + 1; j < length; j++) {

if (ascending) {

if (arr[j] < arr[min]) {

min = j;

}

} else {

if (arr[j] > arr[min]) {

min = j;

}

}

}

swap(arr[i], arr[min]);

}

}

/\*

\* \* insertionSort Function:

\* \* Takes a dynamic array, the length of the array, and whether the array is to be sorted in ascending

\* \* or descending order and then sorts the array

\* \*/

void insertionSort(int\* arr, int length, bool ascending) {

int j;

for (int i = 1; i < length; i++) {

j = i;

if (ascending) {

while ((j > 0) && (arr[j] < arr[j - 1])) {

swap(arr[j], arr[j - 1]);

j = j - 1;

}

} else {

while ((j > 0) && (arr[j] > arr[j - 1])) {

swap(arr[j], arr[j - 1]);

j = j - 1;

}

}

}

}

**Sample Output:**

====================================

Sorting in Ascending order!

Bubble Sort:

Finished at Fri Jan 31 22:39:21 2020

Elapsed time: 1.015e-06s

Amount of swaps 29

Sorted in correct order!

Finished at Fri Jan 31 22:39:21 2020

Elapsed time: 2.619e-06s

Amount of swaps 94

Sorted in correct order!

Finished at Fri Jan 31 22:39:21 2020

Elapsed time: 1.3101e-05s

Amount of swaps 597

Sorted in correct order!

Finished at Fri Jan 31 22:39:21 2020

Elapsed time: 0.00127489s

Amount of swaps 63587

Sorted in correct order!

Finished at Fri Jan 31 22:39:21 2020

Elapsed time: 0.00285609s

Amount of swaps 123771

Sorted in correct order!

Finished at Fri Jan 31 22:39:21 2020

Elapsed time: 0.00542465s

Amount of swaps 252359

Sorted in correct order!

Finished at Fri Jan 31 22:39:22 2020

Elapsed time: 0.266313s

Amount of swaps 6174025

Sorted in correct order!

Finished at Fri Jan 31 22:39:22 2020

Elapsed time: 0.535538s

Amount of swaps 13860518

Sorted in correct order!

Finished at Fri Jan 31 22:39:23 2020

Elapsed time: 0.979812s

Amount of swaps 35675519

Sorted in correct order!

Finished at Fri Jan 31 22:39:27 2020

Elapsed time: 3.85485s

Amount of swaps 154744455

Sorted in correct order!

Finished at Fri Jan 31 22:39:41 2020

Elapsed time: 13.7952s

Amount of swaps 618360705

Sorted in correct order!

Finished at Fri Jan 31 22:40:01 2020

Elapsed time: 20.4153s

Amount of swaps 889843278

Sorted in correct order!

Finished at Fri Jan 31 22:40:55 2020

Elapsed time: 53.7406s

Amount of swaps -1822349058

Sorted in correct order!

====================================

Selection Sort:

Finished at Fri Jan 31 22:40:55 2020

Elapsed time: 6.11e-07s

Amount of swaps 9

Sorted in correct order!

Finished at Fri Jan 31 22:40:55 2020

Elapsed time: 1.319e-06s

Amount of swaps 19

Sorted in correct order!

Finished at Fri Jan 31 22:40:55 2020

Elapsed time: 4.683e-06s

Amount of swaps 49

Sorted in correct order!

Finished at Fri Jan 31 22:40:55 2020

Elapsed time: 0.000280338s

Amount of swaps 499

Sorted in correct order!

Finished at Fri Jan 31 22:40:55 2020

Elapsed time: 0.000592572s

Amount of swaps 699

Sorted in correct order!

Finished at Fri Jan 31 22:40:55 2020

Elapsed time: 0.00119089s

Amount of swaps 999

Sorted in correct order!

Finished at Fri Jan 31 22:40:55 2020

Elapsed time: 0.0588131s

Amount of swaps 4999

Sorted in correct order!

Finished at Fri Jan 31 22:40:55 2020

Elapsed time: 0.136119s

Amount of swaps 7499

Sorted in correct order!

Finished at Fri Jan 31 22:40:56 2020

Elapsed time: 0.334878s

Amount of swaps 11999

Sorted in correct order!

Finished at Fri Jan 31 22:40:57 2020

Elapsed time: 1.02937s

Amount of swaps 24999

Sorted in correct order!

Finished at Fri Jan 31 22:41:00 2020

Elapsed time: 3.42877s

Amount of swaps 49999

Sorted in correct order!

Finished at Fri Jan 31 22:41:05 2020

Elapsed time: 4.78634s

Amount of swaps 59999

Sorted in correct order!

Finished at Fri Jan 31 22:41:16 2020

Elapsed time: 11.5488s

Amount of swaps 99999

Sorted in correct order!

====================================

Insertion Sort:

Finished at Fri Jan 31 22:41:16 2020

Elapsed time: 4.88e-07s

Amount of swaps 23

Sorted in correct order!

Finished at Fri Jan 31 22:41:16 2020

Elapsed time: 1.071e-06s

Amount of swaps 115

Sorted in correct order!

Finished at Fri Jan 31 22:41:16 2020

Elapsed time: 4.464e-06s

Amount of swaps 585

Sorted in correct order!

Finished at Fri Jan 31 22:41:16 2020

Elapsed time: 0.000388089s

Amount of swaps 61223

Sorted in correct order!

Finished at Fri Jan 31 22:41:16 2020

Elapsed time: 0.000816754s

Amount of swaps 114100

Sorted in correct order!

Finished at Fri Jan 31 22:41:16 2020

Elapsed time: 0.00157072s

Amount of swaps 226538

Sorted in correct order!

Finished at Fri Jan 31 22:41:16 2020

Elapsed time: 0.095757s

Amount of swaps 6168673

Sorted in correct order!

Finished at Fri Jan 31 22:41:17 2020

Elapsed time: 0.208121s

Amount of swaps 13847842

Sorted in correct order!

Finished at Fri Jan 31 22:41:17 2020

Elapsed time: 0.541232s

Amount of swaps 35053982

Sorted in correct order!

Finished at Fri Jan 31 22:41:19 2020

Elapsed time: 1.45516s

Amount of swaps 154705883

Sorted in correct order!

Finished at Fri Jan 31 22:41:24 2020

Elapsed time: 5.53535s

Amount of swaps 618735302

Sorted in correct order!

Finished at Fri Jan 31 22:41:31 2020

Elapsed time: 7.16654s

Amount of swaps 891103042

Sorted in correct order!

Finished at Fri Jan 31 22:41:51 2020

Elapsed time: 19.8198s

Amount of swaps -1814887115

Sorted in correct order!

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Sorting in Descending order!

Bubble Sort:

Finished at Fri Jan 31 22:41:51 2020

Elapsed time: 5.41e-07s

Amount of swaps 21

Sorted in correct order!

Finished at Fri Jan 31 22:41:51 2020

Elapsed time: 2.14e-06s

Amount of swaps 95

Sorted in correct order!

Finished at Fri Jan 31 22:41:51 2020

Elapsed time: 1.132e-05s

Amount of swaps 744

Sorted in correct order!

Finished at Fri Jan 31 22:41:51 2020

Elapsed time: 0.000987904s

Amount of swaps 63728

Sorted in correct order!

Finished at Fri Jan 31 22:41:51 2020

Elapsed time: 0.00213603s

Amount of swaps 123341

Sorted in correct order!

Finished at Fri Jan 31 22:41:51 2020

Elapsed time: 0.00484593s

Amount of swaps 241637

Sorted in correct order!

Finished at Fri Jan 31 22:41:52 2020

Elapsed time: 0.259896s

Amount of swaps 6193985

Sorted in correct order!

Finished at Fri Jan 31 22:41:52 2020

Elapsed time: 0.530735s

Amount of swaps 13983585

Sorted in correct order!

Finished at Fri Jan 31 22:41:53 2020

Elapsed time: 0.970287s

Amount of swaps 35595930

Sorted in correct order!

Finished at Fri Jan 31 22:41:57 2020

Elapsed time: 3.95241s

Amount of swaps 153894287

Sorted in correct order!

Finished at Fri Jan 31 22:42:11 2020

Elapsed time: 13.754s

Amount of swaps 617829845

Sorted in correct order!

Finished at Fri Jan 31 22:42:32 2020

Elapsed time: 20.9526s

Amount of swaps 889982409

Sorted in correct order!

Finished at Fri Jan 31 22:43:26 2020

Elapsed time: 54.4633s

Amount of swaps -1820890512

Sorted in correct order!

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Selection Sort:

Finished at Fri Jan 31 22:43:26 2020

Elapsed time: 5.47e-07s

Amount of swaps 9

Sorted in correct order!

Finished at Fri Jan 31 22:43:26 2020

Elapsed time: 1.262e-06s

Amount of swaps 19

Sorted in correct order!

Finished at Fri Jan 31 22:43:26 2020

Elapsed time: 4.727e-06s

Amount of swaps 49

Sorted in correct order!

Finished at Fri Jan 31 22:43:26 2020

Elapsed time: 0.00027756s

Amount of swaps 499

Sorted in correct order!

Finished at Fri Jan 31 22:43:26 2020

Elapsed time: 0.00060062s

Amount of swaps 699

Sorted in correct order!

Finished at Fri Jan 31 22:43:26 2020

Elapsed time: 0.00112012s

Amount of swaps 999

Sorted in correct order!

Finished at Fri Jan 31 22:43:26 2020

Elapsed time: 0.0583566s

Amount of swaps 4999

Sorted in correct order!

Finished at Fri Jan 31 22:43:26 2020

Elapsed time: 0.132736s

Amount of swaps 7499

Sorted in correct order!

Finished at Fri Jan 31 22:43:27 2020

Elapsed time: 0.336948s

Amount of swaps 11999

Sorted in correct order!

Finished at Fri Jan 31 22:43:28 2020

Elapsed time: 0.972218s

Amount of swaps 24999

Sorted in correct order!

Finished at Fri Jan 31 22:43:31 2020

Elapsed time: 3.39553s

Amount of swaps 49999

Sorted in correct order!

Finished at Fri Jan 31 22:43:36 2020

Elapsed time: 4.85969s

Amount of swaps 59999

Sorted in correct order!

Finished at Fri Jan 31 22:43:48 2020

Elapsed time: 11.5848s

Amount of swaps 99999

Sorted in correct order!

====================================

Insertion Sort:

Finished at Fri Jan 31 22:43:48 2020

Elapsed time: 4.7e-07s

Amount of swaps 27

Sorted in correct order!

Finished at Fri Jan 31 22:43:48 2020

Elapsed time: 1.075e-06s

Amount of swaps 110

Sorted in correct order!

Finished at Fri Jan 31 22:43:48 2020

Elapsed time: 4.685e-06s

Amount of swaps 636

Sorted in correct order!

Finished at Fri Jan 31 22:43:48 2020

Elapsed time: 0.000462322s

Amount of swaps 59808

Sorted in correct order!

Finished at Fri Jan 31 22:43:48 2020

Elapsed time: 0.000872578s

Amount of swaps 117888

Sorted in correct order!

Finished at Fri Jan 31 22:43:48 2020

Elapsed time: 0.0018404s

Amount of swaps 247885

Sorted in correct order!

Finished at Fri Jan 31 22:43:48 2020

Elapsed time: 0.0989315s

Amount of swaps 6153560

Sorted in correct order!

Finished at Fri Jan 31 22:43:48 2020

Elapsed time: 0.213291s

Amount of swaps 13845842

Sorted in correct order!

Finished at Fri Jan 31 22:43:48 2020

Elapsed time: 0.560375s

Amount of swaps 35612717

Sorted in correct order!

Finished at Fri Jan 31 22:43:50 2020

Elapsed time: 1.45668s

Amount of swaps 155367411

Sorted in correct order!

Finished at Fri Jan 31 22:43:55 2020

Elapsed time: 5.35506s

Amount of swaps 619475300

Sorted in correct order!

Finished at Fri Jan 31 22:44:02 2020

Elapsed time: 7.13053s

Amount of swaps 892259478

Sorted in correct order!

Finished at Fri Jan 31 22:44:23 2020

Elapsed time: 21.0801s

Amount of swaps -1820071965

Sorted in correct order!

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Sorting Worst Case scenario!

Bubble Sort:

Finished at Fri Jan 31 22:44:23 2020

Elapsed time: 8.7e-07s

Amount of swaps 45

Sorted in correct order!

Finished at Fri Jan 31 22:44:23 2020

Elapsed time: 2.31e-06s

Amount of swaps 190

Sorted in correct order!

Finished at Fri Jan 31 22:44:23 2020

Elapsed time: 1.2354e-05s

Amount of swaps 1225

Sorted in correct order!

Finished at Fri Jan 31 22:44:23 2020

Elapsed time: 0.00119682s

Amount of swaps 124750

Sorted in correct order!

Finished at Fri Jan 31 22:44:23 2020

Elapsed time: 0.00236826s

Amount of swaps 244650.

Sorted in correct order!

Finished at Fri Jan 31 22:44:23 2020

Elapsed time: 0.00531774s

Amount of swaps 499500

Sorted in correct order!

Finished at Fri Jan 31 22:44:24 2020

Elapsed time: 0.361942s

Amount of swaps 12497500

Sorted in correct order!

Finished at Fri Jan 31 22:44:24 2020

Elapsed time: 0.61019s

Amount of swaps 28121250

Sorted in correct order!

Finished at Fri Jan 31 22:44:26 2020

Elapsed time: 1.24262s

Amount of swaps 71994000

Sorted in correct order!

Finished at Fri Jan 31 22:44:30 2020

Elapsed time: 4.79895s

Amount of swaps 312487500

Sorted in correct order!

====================================

Selection Sort:

Finished at Fri Jan 31 22:44:30 2020

Elapsed time: 5.29e-07s

Amount of swaps 9

Sorted in correct order!

Finished at Fri Jan 31 22:44:30 2020

Elapsed time: 1.16e-06s

Amount of swaps 19

Sorted in correct order!

Finished at Fri Jan 31 22:44:30 2020

Elapsed time: 4.065e-06s

Amount of swaps 49

Sorted in correct order!

Finished at Fri Jan 31 22:44:30 2020

Elapsed time: 0.000315295s

Amount of swaps 499

Sorted in correct order!

Finished at Fri Jan 31 22:44:30 2020

Elapsed time: 0.000748303s

Amount of swaps 699

Sorted in correct order!

Finished at Fri Jan 31 22:44:30 2020

Elapsed time: 0.00140218s

Amount of swaps 999

Sorted in correct order!

====================================

Insertion Sort:

Finished at Fri Jan 31 22:44:30 2020

Elapsed time: 1.6652e-05s

Amount of swaps 45

Sorted in correct order!

Finished at Fri Jan 31 22:44:30 2020

Elapsed time: 1.588e-06s

Amount of swaps 190

Sorted in correct order!

Finished at Fri Jan 31 22:44:30 2020

Elapsed time: 8.537e-06s

Amount of swaps 1225

Sorted in correct order!

Finished at Fri Jan 31 22:44:30 2020

Elapsed time: 0.000933844s

Amount of swaps 124750

Sorted in correct order!

Finished at Fri Jan 31 22:44:30 2020

Elapsed time: 0.00204522s

Amount of swaps 244650

Sorted in correct order!

Finished at Fri Jan 31 22:44:30 2020

Elapsed time: 0.00840729s

Amount of swaps 499500

Sorted in correct order!

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