Algorithms

Programming Assignment #1

Sorting

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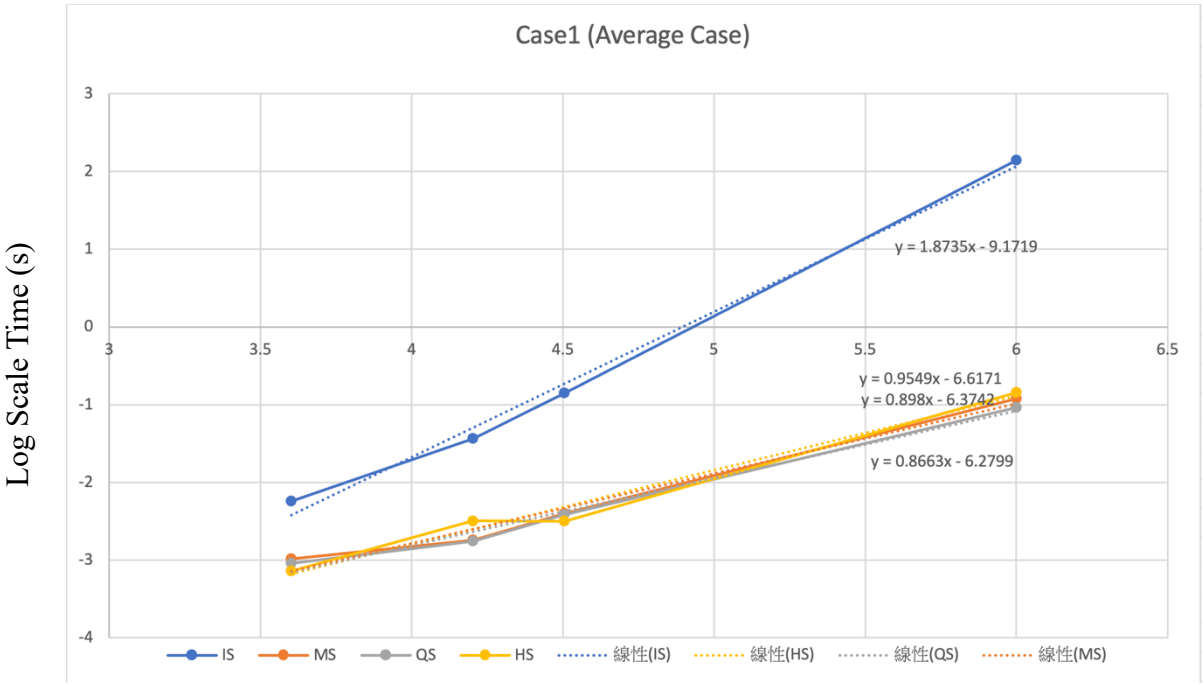
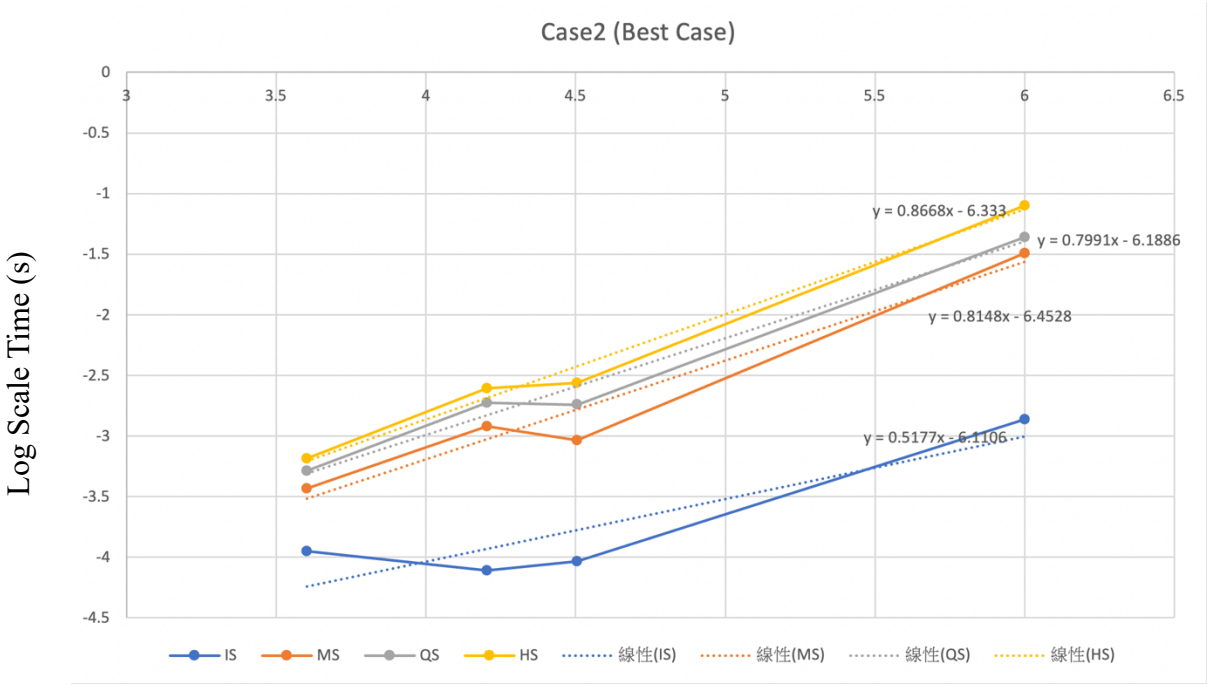
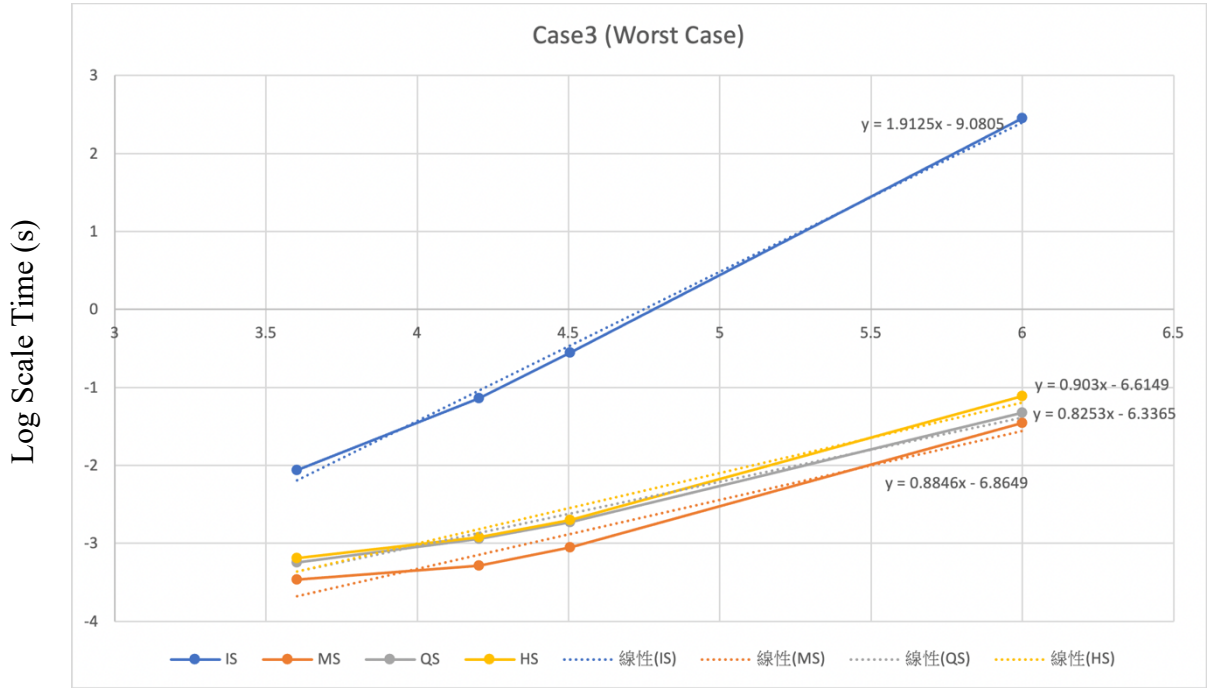
Input size	IS		MS		QS		HS	
	CPU time (s)	Memory (KB)	CPU time (s)	Memory (KB)	CPU time (s)	Memory (KB)	CPU time (s)	Memory (KB)
4000.case1	0.005693	5904	0.001036	5904	0.0009	5904	0.00072	5904
4000.case2	0.000112	5904	0.000366	5904	0.000514	5904	0.000652	5904
4000.case3	0.008708	5904	0.000342	5904	0.000574	5904	0.000643	5904
16000.case1	0.036731	6048	0.001795	6048	0.001754	6048	0.003186	6056
16000.case2	0.000077	6048	0.001193	6048	0.001867	6048	0.002464	6056
16000.case3	0.072557	6048	0.000517	6048	0.001146	6048	0.001204	6056
32000.case1	0.141271	6180	0.003976	6180	0.003824	6180	0.003171	6188
32000.case2	0.000092	6180	0.000919	6180	0.001809	6180	0.002727	6188
32000.case3	0.277834	6180	0.000887	6180	0.001878	6180	0.002002	6188
1000000.case1	140.98	12136	0.119604	13868	0.091795	12136	0.14274	12144
1000000.case2	0.001373	12136	0.032077	13868	0.043553	12136	0.079283	12144
1000000.case3	284.388	12136	0.03489	13868	0.047258	12136	0.076889	12144




Case2 (Best Case)
Log Scale Time (s)
Log Scale input size
y = 0.8668x - 6.333
y = 0.7991x - 6.1886
y = 0.8148x - 6.4528
y = 0.5177x - 6.1106
IS
MS
QS
HS
線性(IS)
線性(MS)
線性(QS)
線性(HS)


Case3 (Worst Case)
Log Scale Time (s)
Log Scale input size
y = 1.9125x - 9.0805
y = 0.903x - 6.6149
y = 0.8253x - 6.3365
y = 0.8846x - 6.8649
IS
MS
QS
HS
線性(IS)
線性(MS)
線性(QS)
線性(HS)

Insight:

First relation must be larger input, longer time from positive slope.

Input size	IS		MS		QS		HS	
	CPU time (s)	Memory (KB)	CPU time (s)	Memory (KB)	CPU time (s)	Memory (KB)	CPU time (s)	Memory (KB)
4000.case1	0.005693	5904	0.001036	5904	0.0009	5904	0.00072	5904
4000.case2	0.000112	5904	0.000366	5904	0.000514	5904	0.000652	5904
4000.case3	0.008708	5904	0.000342	5904	0.000574	5904	0.000643	5904
16000.case1	0.036731	6048	0.001795	6048	0.001754	6048	0.003186	6056
16000.case2	0.000077	6048	0.001193	6048	0.001867	6048	0.002464	6056
16000.case3	0.072557	6048	0.000517	6048	0.001146	6048	0.001204	6056
32000.case1	0.141271	6180	0.003976	6180	0.003824	6180	0.003171	6188
32000.case2	0.000092	6180	0.000919	6180	0.001809	6180	0.002727	6188
32000.case3	0.277834	6180	0.000887	6180	0.001878	6180	0.002002	6188
1000000.case1	140.98	12136	0.119604	13868	0.091795	12136	0.14274	12144
1000000.case2	0.001373	12136	0.032077	13868	0.043553	12136	0.079283	12144
1000000.case3	284.388	12136	0.03489	13868	0.047258	12136	0.076889	12144

Green = better, Red = Worse

Secondly, in average case:
Insertion sort performs the slowest in general. All other 3 sorting is around the same, heap sort did slower than merge sort and quick sort.

Third, in best case:
Slope of insertion sort is the smallest, indicating increasing input, time increase will not rise a lot. Moreso, from the color graph (all green in case 2) and slope graph (the line of insertion sort below others), insertion sort did the best in time complexity among all 4 algorithms. Therefore, in sorted already case, insertion sort is the fastest.

Forth, in worst case:
Insertion sort is the slowest while merge sort is the fastest. Merge sort generally performs fewer comparisons than quicksort both in the worst-case and on average.

Fifth, for input size:
While in small number input (4000 input), insertion sort is the fastest while heap sort is the slowest in time. While in larger input, insertion sort did the slowest in both average case and worst case.

Sixth, for memory:
All around the same except merge sort and heapsort used slightly more in 1,000,000 input case.

Thanks so much TA!

Appendix

Excel used:
https://hkustconnect-my.sharepoint.com/:x:/g/personal/lhchanar_connect_ust_hk/EYcblak1tHxMtxOfyctN8W8BzmTWvlhza9On1LxF7cj5gA?e=l8cemh

Log Scale Time (s)

case1				
Input (Log)	IS	MS	QS	HS
3.602059991	-2.24465882	-2.9846402	-3.0457575	-3.1426675
4.204119983	-1.43496725	-2.7459355	-2.7559704	-2.4967542
4.505149978	-0.84994698	-2.4005536	-2.4174821	-2.4988038
6	2.14915751	-0.9222543	-1.037181	-0.8454543
Slope	1.87354533	0.89798884	0.86630954	0.95486727

Log Scale Time (s)

case2				
Input (Log)	IS	MS	QS	HS
3.602059991	-3.95078198	-3.4365189	-3.2890369	-3.1857524
4.204119983	-4.11350927	-2.9233596	-2.7288557	-2.6083593
4.505149978	-4.03621217	-3.0366845	-2.7425614	-2.5643149
6	-2.86232946	-1.4938063	-1.3609819	-1.1008199
Slope	0.51768354	0.81484751	0.799116	0.86682434

n

Log Scale Time (s)

case3				
Input (Log)	IS	MS	QS	HS
3.602059991	-2.06008158	-3.4659739	-3.2410881	-3.191789
4.204119983	-1.13932068	-3.2865095	-2.9408154	-2.9193735
4.505149978	-0.55621461	-3.0520764	-2.7263044	-2.6985359
6	2.45391127	-1.457299	-1.3255247	-1.1141358
Slope	1.9124824	0.88456498	0.82529516	0.90302677

```
alg22s050@edaU11:~$ cd PA_Andrew
-bash: cd: PA_Andrew: No such file or directory
alg22s050@edaU11:~$ cd PA1_Andrew
alg22s050@edaU11:~/PA1_Andrew$ ls
bin  doc  inputs  lib  main_opt.o  makefile  output  outputs  README  src  tm_usage.o  utility
alg22s050@edaU11:~/PA1_Andrew$ make
g++ -c -O2 src/sort_tool.cpp -o sort_tool_opt.o
g++ -c src/main.cpp -Ilib -o main_opt.o
g++ -c lib/tm_usage.cpp
ar rcv lib/libtm_usage.a tm_usage.o
r - tm_usage.o
g++ -O2 sort_tool_opt.o main_opt.o -ltm_usage -Llib -o bin/NTU_sort
alg22s050@edaU11:~/PA1_Andrew$ cd binalg22s050@edaU11:~/PA1_Andrew/bin$ ./NTU_sort -IS ../inputs/4000.case1.in ../outputs/4000.case1.o
ut
The total CPU time: 5.693ms
memory: 5904KB
alg22s050@edaU11:~/PA1_Andrew/bin$ ./NTU_sort -IS ../inputs/4000.case2.in ../outputs/4000.case2.out
The total CPU time: 0.112ms
memory: 5904KB
alg22s050@edaU11:~/PA1_Andrew/bin$ ./NTU_sort -IS ../inputs/4000.case3.in ../outputs/4000.case3.out
The total CPU time: 8.708ms
memory: 5904KB
alg22s050@edaU11:~/PA1_Andrew/bin$ ./NTU_sort -IS ../inputs/16000.case1.in ../outputs/16000.case1.out
The total CPU time: 36.731ms
memory: 6048KB
alg22s050@edaU11:~/PA1_Andrew/bin$ ./NTU_sort -IS ../inputs/16000.case2.in ../outputs/16000.case2.out
The total CPU time: 0.077ms
memory: 6048KB
alg22s050@edaU11:~/PA1_Andrew/bin$ ./NTU_sort -IS ../inputs/16000.case3.in ../outputs/16000.case3.out
The total CPU time: 72.557ms
memory: 6048KB
alg22s050@edaU11:~/PA1_Andrew/bin$ ./NTU_sort -IS ../inputs/32000.case1.in ../outputs/32000.case1.out
The total CPU time: 141.271ms
memory: 6180KB
alg22s050@edaU11:~/PA1_Andrew/bin$ ./NTU_sort -IS ../inputs/32000.case2.in ../outputs/32000.case2.out
The total CPU time: 0.092ms
memory: 6180KB
alg22s050@edaU11:~/PA1_Andrew/bin$ ./NTU_sort -IS ../inputs/32000.case3.in ../outputs/32000.case3.out
The total CPU time: 277.834ms
memory: 6180KB
alg22s050@edaU11:~/PA1_Andrew/bin$ ./NTU_sort -IS ../inputs/1000000.case1.in ../outputs/1000000.case1.out
The total CPU time: 140980ms
memory: 12136KB
alg22s050@edaU11:~/PA1_Andrew/bin$ ./NTU_sort -IS ../inputs/1000000.case2.in ../outputs/1000000.case2.out
The total CPU time: 1.373ms
memory: 12136KB
alg22s050@edaU11:~/PA1_Andrew/bin$ ./NTU_sort -IS ../inputs/1000000.case3.in ../outputs/1000000.case3.out
The total CPU time: 284388ms
memory: 12136KB
alg22s050@edaU11:~/PA1_Andrew/bin$
```

Insertion Sort

```
alg22s050@edaU11:~/PA1_Andrew/bin$ ./NTU_sort -MS ../inputs/4000.case1.in ../outputs/4000.case1.out
The total CPU time: 1.036ms
memory: 5904KB
alg22s050@edaU11:~/PA1_Andrew/bin$ ./NTU_sort -MS ../inputs/4000.case2.in ../outputs/4000.case2.out
The total CPU time: 0.366ms
memory: 5904KB
alg22s050@edaU11:~/PA1_Andrew/bin$ ./NTU_sort -MS ../inputs/4000.case3.in ../outputs/4000.case3.out
The total CPU time: 0.342ms
memory: 5904KB
alg22s050@edaU11:~/PA1_Andrew/bin$ ./NTU_sort -MS ../inputs/16000.case1.in ../outputs/16000.case1.out
The total CPU time: 1.795ms
memory: 6048KB
alg22s050@edaU11:~/PA1_Andrew/bin$ ./NTU_sort -MS ../inputs/16000.case2.in ../outputs/16000.case2.out
The total CPU time: 1.193ms
memory: 6048KB
alg22s050@edaU11:~/PA1_Andrew/bin$ ./NTU_sort -MS ../inputs/16000.case3.in ../outputs/16000.case3.out
The total CPU time: 0.517ms
memory: 6048KB
alg22s050@edaU11:~/PA1_Andrew/bin$ ./NTU_sort -MS ../inputs/32000.case1.in ../outputs/32000.case1.out
The total CPU time: 3.976ms
memory: 6180KB
alg22s050@edaU11:~/PA1_Andrew/bin$ ./NTU_sort -MS ../inputs/32000.case2.in ../outputs/32000.case2.out
The total CPU time: 0.919ms
memory: 6180KB
alg22s050@edaU11:~/PA1_Andrew/bin$ ./NTU_sort -MS ../inputs/32000.case3.in ../outputs/32000.case3.out
The total CPU time: 0.887ms
memory: 6180KB
alg22s050@edaU11:~/PA1_Andrew/bin$ ./NTU_sort -MS ../inputs/1000000.case1.in ../outputs/1000000.case1.out
The total CPU time: 119.604ms
memory: 13868KB
alg22s050@edaU11:~/PA1_Andrew/bin$ ./NTU_sort -MS ../inputs/1000000.case2.in ../outputs/1000000.case2.out
The total CPU time: 32.077ms
memory: 13868KB
alg22s050@edaU11:~/PA1_Andrew/bin$ ./NTU_sort -MS ../inputs/1000000.case3.in ../outputs/1000000.case3.out
The total CPU time: 34.89ms
memory: 13868KB
```

Merge Sort

```
alg22s050@edaU11:~/PA1_Andrew/bin$ ./NTU_sort -QS ../inputs/4000.case1.in ../outputs/4000.case1.out
The total CPU time: 0.9ms
memory: 5904KB
alg22s050@edaU11:~/PA1_Andrew/bin$ ./NTU_sort -QS ../inputs/4000.case2.in ../outputs/4000.case2.out
The total CPU time: 0.514ms
memory: 5904KB
alg22s050@edaU11:~/PA1_Andrew/bin$ ./NTU_sort -QS ../inputs/4000.case3.in ../outputs/4000.case3.out
The total CPU time: 0.574ms
memory: 5904KB
alg22s050@edaU11:~/PA1_Andrew/bin$ ./NTU_sort -QS ../inputs/16000.case1.in ../outputs/16000.case1.out
The total CPU time: 1.754ms
memory: 6048KB
alg22s050@edaU11:~/PA1_Andrew/bin$ ./NTU_sort -QS ../inputs/16000.case2.in ../outputs/16000.case2.out
The total CPU time: 1.867ms
memory: 6048KB
alg22s050@edaU11:~/PA1_Andrew/bin$ ./NTU_sort -QS ../inputs/16000.case3.in ../outputs/16000.case3.out
The total CPU time: 1.146ms
memory: 6048KB
alg22s050@edaU11:~/PA1_Andrew/bin$ ./NTU_sort -QS ../inputs/32000.case1.in ../outputs/32000.case1.out
The total CPU time: 3.824ms
memory: 6180KB
alg22s050@edaU11:~/PA1_Andrew/bin$ ./NTU_sort -QS ../inputs/32000.case2.in ../outputs/32000.case2.out
The total CPU time: 1.809ms
memory: 6180KB
alg22s050@edaU11:~/PA1_Andrew/bin$ ./NTU_sort -QS ../inputs/32000.case3.in ../outputs/32000.case3.out
The total CPU time: 1.878ms
memory: 6180KB
alg22s050@edaU11:~/PA1_Andrew/bin$ ./NTU_sort -QS ../inputs/1000000.case1.in ../outputs/1000000.case1.out
The total CPU time: 91.795ms
memory: 12136KB
alg22s050@edaU11:~/PA1_Andrew/bin$ ./NTU_sort -QS ../inputs/1000000.case2.in ../outputs/1000000.case2.out
The total CPU time: 43.553ms
memory: 12136KB
alg22s050@edaU11:~/PA1_Andrew/bin$ ./NTU_sort -QS ../inputs/1000000.case3.in ../outputs/1000000.case3.out
The total CPU time: 47.258ms
memory: 12136KB
```

Quick Sort

```
alg22s050@edaU11:~/PA1_T10902309/bin$ ./NTU_sort -HS ../inputs/4000.case1.in ../outputs/4000.case1.out
The total CPU time: 0.76ms
memory: 5904KB
alg22s050@edaU11:~/PA1_T10902309/bin$ ./NTU_sort -HS ../inputs/4000.case2.in ../outputs/4000.case2.out
The total CPU time: 0.652ms
memory: 5904KB
alg22s050@edaU11:~/PA1_T10902309/bin$ ./NTU_sort -HS ../inputs/4000.case3.in ../outputs/4000.case3.out
The total CPU time: 0.643ms
memory: 5904KB
alg22s050@edaU11:~/PA1_T10902309/bin$ ./NTU_sort -HS ../inputs/16000.case1.in ../outputs/16000.case1.out
The total CPU time: 3.186ms
memory: 6056KB
alg22s050@edaU11:~/PA1_T10902309/bin$ ./NTU_sort -HS ../inputs/16000.case2.in ../outputs/16000.case2.out
The total CPU time: 2.464ms
memory: 6056KB
alg22s050@edaU11:~/PA1_T10902309/bin$ ./NTU_sort -HS ../inputs/16000.case3.in ../outputs/16000.case3.out
The total CPU time: 1.204ms
memory: 6056KB
alg22s050@edaU11:~/PA1_T10902309/bin$ ./NTU_sort -HS ../inputs/32000.case1.in ../outputs/32000.case1.out
The total CPU time: 3.171ms
memory: 6188KB
alg22s050@edaU11:~/PA1_T10902309/bin$ ./NTU_sort -HS ../inputs/32000.case2.in ../outputs/32000.case2.out
The total CPU time: 2.727ms
memory: 6188KB
alg22s050@edaU11:~/PA1_T10902309/bin$ ./NTU_sort -HS ../inputs/32000.case3.in ../outputs/32000.case3.out
The total CPU time: 2.002ms
memory: 6188KB
alg22s050@edaU11:~/PA1_T10902309/bin$ ./NTU_sort -HS ../inputs/1000000.case1.in ../outputs/1000000.case1.out
The total CPU time: 142.74ms
memory: 12144KB
alg22s050@edaU11:~/PA1_T10902309/bin$ ./NTU_sort -HS ../inputs/1000000.case2.in ../outputs/1000000.case2.out
The total CPU time: 79.283ms
memory: 12144KB
alg22s050@edaU11:~/PA1_T10902309/bin$ ./NTU_sort -HS ../inputs/1000000.case3.in ../outputs/1000000.case3.out
The total CPU time: 76.889ms
memory: 12144KB
```

Heap Sort