DSA Homework 1 Report

Question 1

Python code is a separate file.
Plot of the time cost as a function of input numbers:

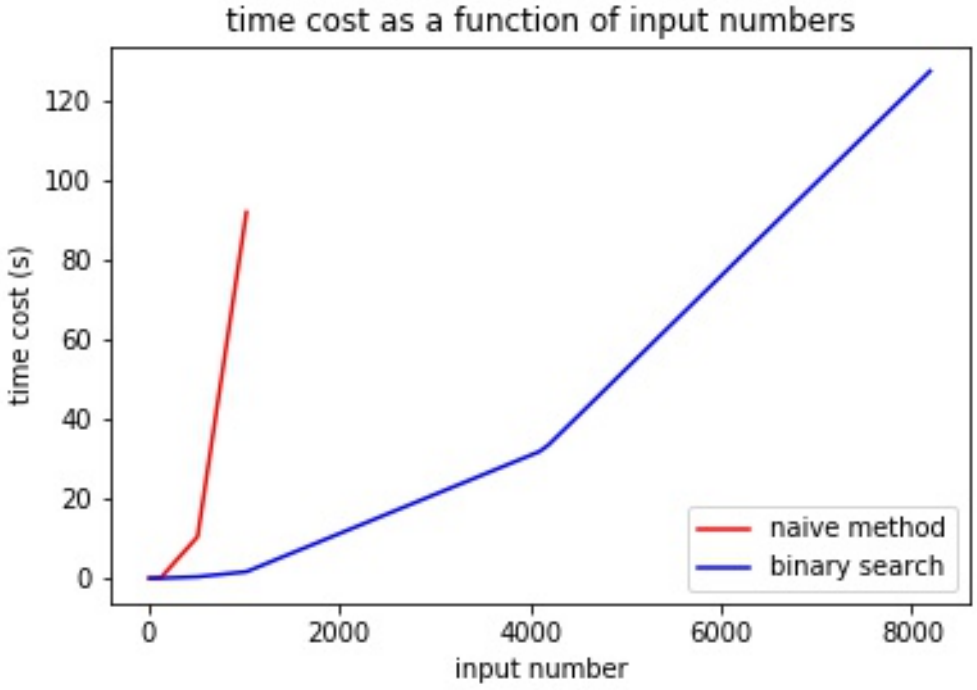


Table of data:

Input size	8	32	128	512	1024	4096	4192	8192
Time of naïve method (s)	0.016923	0.022375	0.187438	10.458159	91.951641	N/A	N/A	N/A
Time of binary method (s)	0.017953	0.024934	0.040442	0.390084	1.654021	31.834062	33.529971	127.38970

Discussion and analysis:
Run time for naïve method with input size 4096 and bigger is too long to record.
For the naïve method, since each number in input array will be checked through three loops, big O for this method will be n^3.
For the binary method, which takes binary search instead of the third, as well as the most inner loop check, it costs n^2 first to sort the input array and then takes $n^2 \log n$ to do the outer two loops and binary search. Since $n^2 \log n$ also bounds n^2, the big O for this method is simply $n^2 \log n$.
We can tell from the plot that time cost of the binary method grows slower than the naïve method.

Question 2

Python code is a separate file.

Plot of the time cost as a function of input numbers:

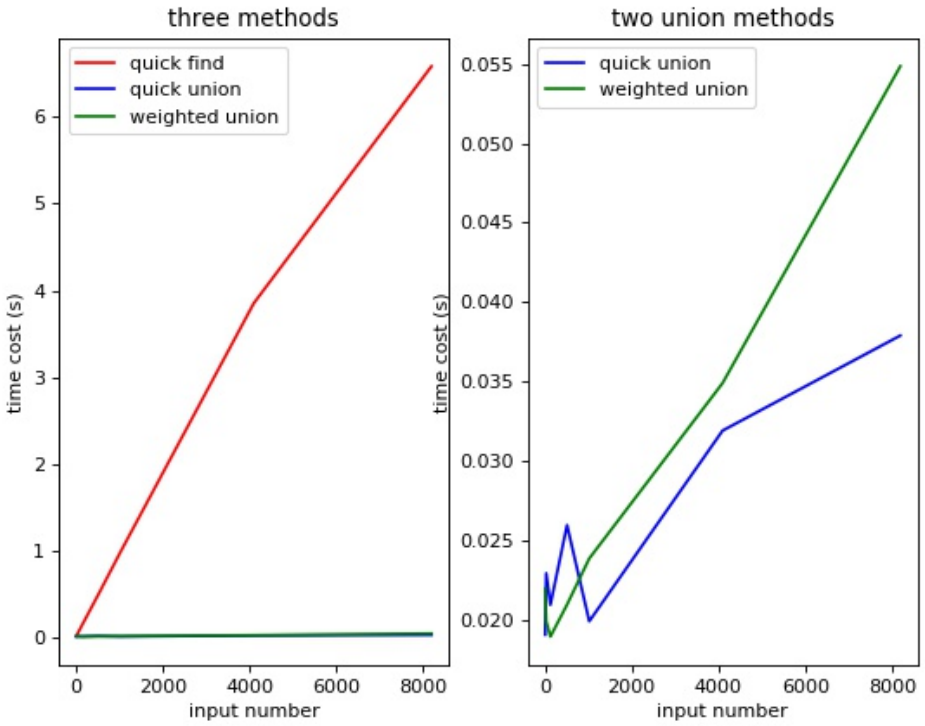


Table of data:

Input size	8	32	128	512	1024	4096	8192
Time of quick find (s)	0.028948	0.048844	0.141051	0.501474	0.992458	3.854294	6.581416
Time of quick union (s)	0.021939	0.020977	0.025932	0.023901	0.024933	0.031916	0.042885
Time of weighted union (s)	0.020944	0.017952	0.020945	0.020943	0.022939	0.033911	0.049897

Discussion and analysis:

Run time of quick find has big O of n. From the plot we can tell it is almost a straight line with the increasing of input size. From the left plot, we can tell that both union methods grow much slower than the quick find method.

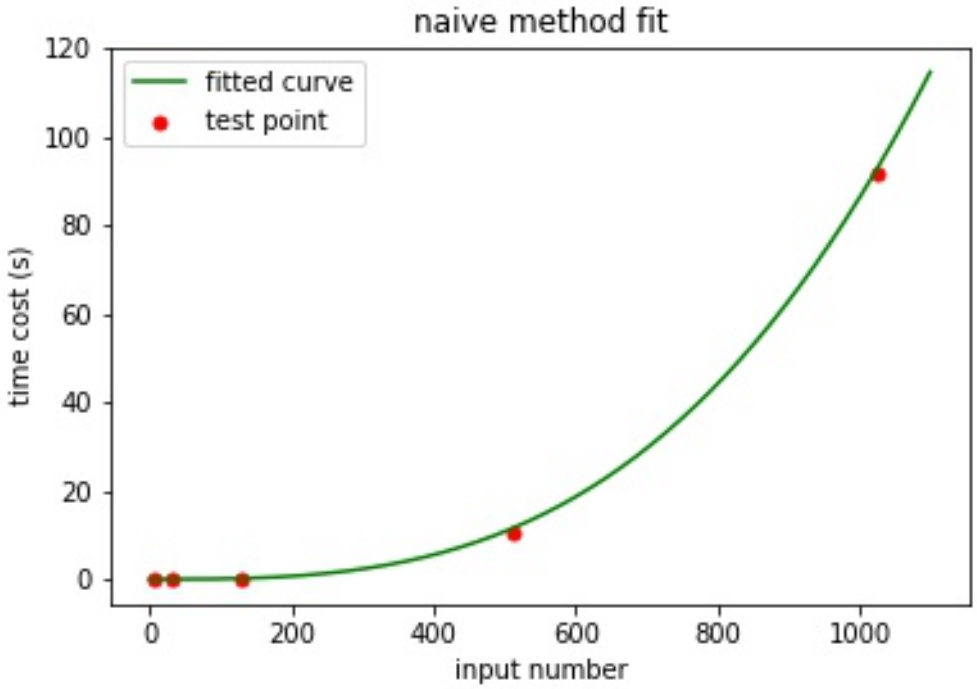
For both union methods, the weighted union method is designed to perform better but as the result doesn't have significant difference between it and the quick union method. One possible reason may be that the input size is not big enough to have tall tree in quick union method to show the difference.

Question 3

Python code is a separate file.

Fro Q1 naïve method:

Plot of fitted curve:



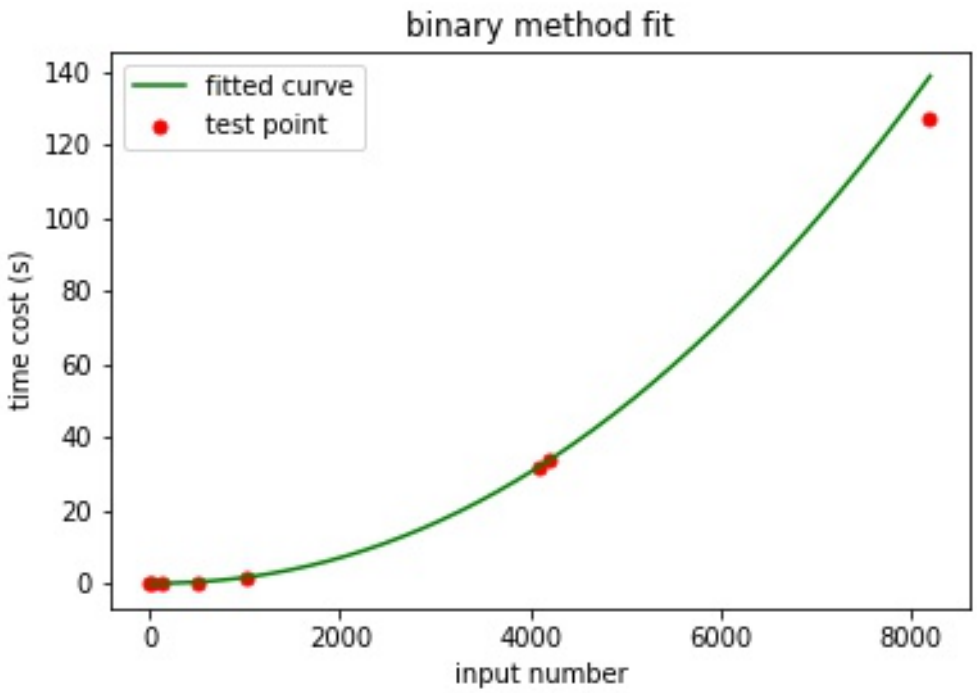
Input size	8	32	128	512	1024	4096	4192	8192
Time of test (s)	0.016923	0.022375	0.187438	10.458159	91.951641	N/A	N/A	N/A
Time of fit (s)	0.000044	0.002830	0.181138	11.592802	92.742416			

Discussion:

In fitting result, c = 8.55179267e-08. But for the big O bunding the test result, I choose c' = 1.01*c = 8.63731059e-08. Nc here is 512 when time of fit starts to become bigger than time of test.

For Q1 binary method:

Fitted curve of binary method:

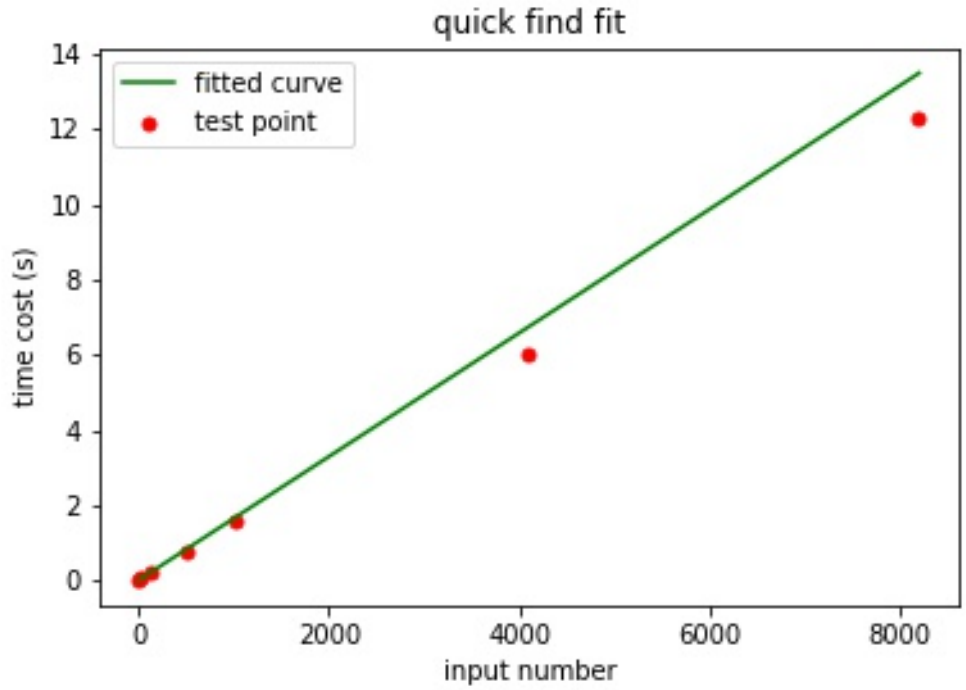


Input size	8	32	128	512	1024	4096	4192	8192
Time of test (s)	0.017953	0.024934	0.040442	0.390084	1.654021	31.834062	33.529971	127.389705
Time of fit (s)	0.000041	0.000874	0.018556	0.376818	1.671196	32.036444	33.648810	138.788515

Discussion:

In fitting result, c = 1.47263334e-07. But for the big O bunding the test result, I choose c' = 1.08*c = 1.47263334e-07. Nc here is 1024 when time of fit starts to become bigger than time of test.

Fitted curve for quick find in Q2:



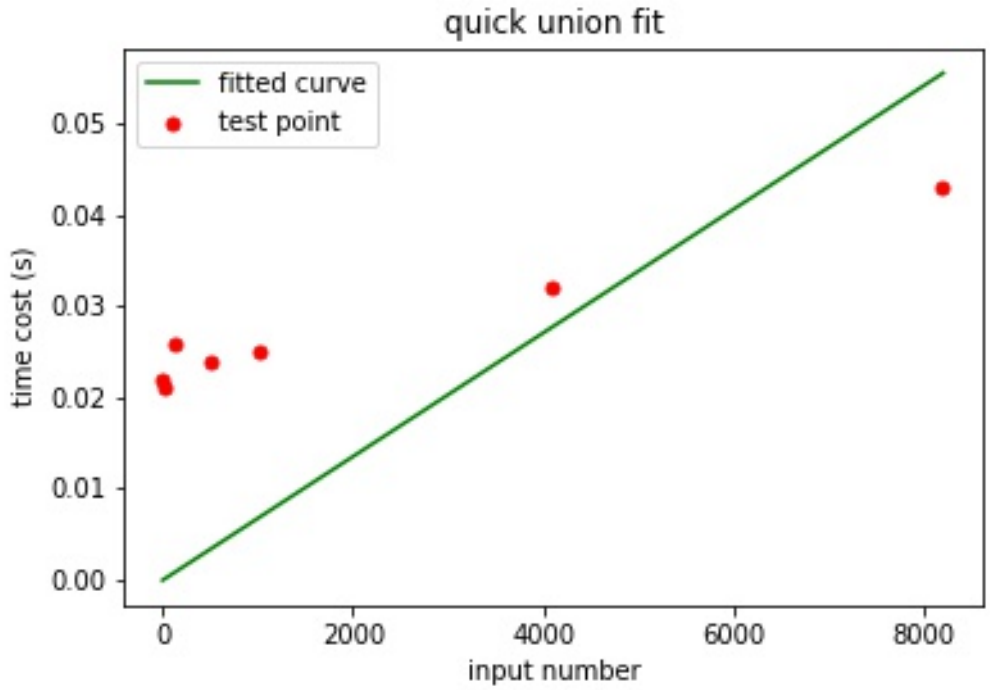
Input size	8	32	128	512	1024	4096	8192
Time of quick find (s)	0.039919	0.063803	0.209440	0.784708	1.551888	6.044102	12.291668
Fitted time (s)	0.014809	0.054300	0.212265	0.844123	1.686601	6.741468	13.481291

Discussion:

In fitting result, c = 0.00149588. But for the big O bunding the test result, I choose

c' = 1.1*c = 0.00164546. Nc here is 128 when time of fit starts to become bigger than time of test.

Fitted curve for quick union in Q2:

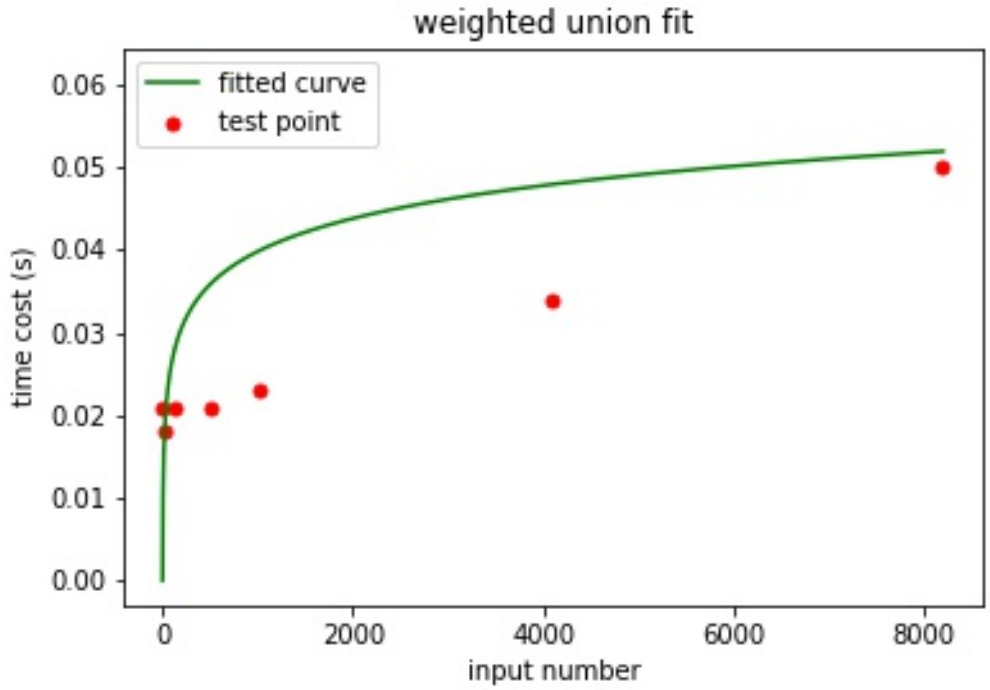


Input size	8	32	128	512	1024	4096	8192
Time of quick find (s)	0.021939	0.020977	0.025932	0.023901	0.024933	0.031916	0.042885
Fitted time (s)	0.000061	0.000223	0.000873	0.003470	0.006933	0.027711	0.055416

Discussion:

In fitting result, c = 6.14893045e-06. But for the big O bunding the test result, I choose c' = 1.1*c = 6.7638235e-06. Nc here is 8192 when time of fit starts to become bigger than time of test.

Fitted curve for weighted union in Q2:



Input size	8	32	128	512	1024	4096	8192
Time of quick find (s)	0.020944	0.017952	0.020945	0.020943	0.022939	0.033911	0.049897
Fitted time (s)	0.012660	0.020147	0.028002	0.035956	0.039945	0.047928	0.051921

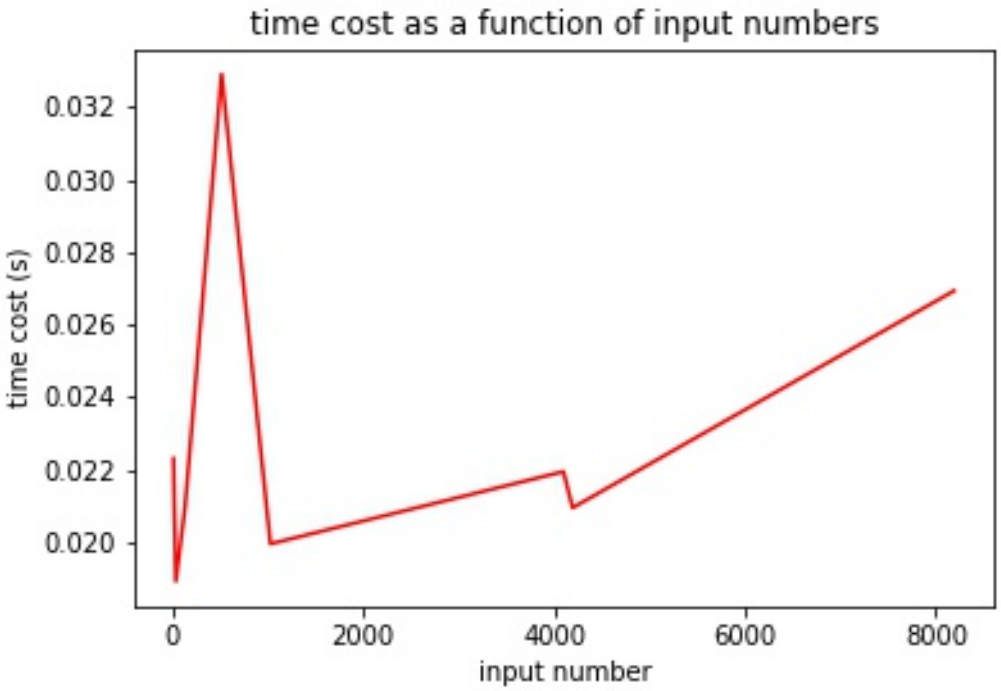
Discussion:

In fitting result, c = 0.00307223. But for the big O bunding the test result, I choose

c’ = 1.1*c = 0.0039939. Nc here is 32 when time of fit starts to become bigger than time of test.

Question 4:

Python code is a separate file.
In this question, the program should only find the maximum and minimum value of the array. This task can be done within one loop of all input. Since the task will be done within one loop, the running time should grow in order n. In reality, 8k input size may not big enough for python to clearly show the growth order, so the plot of runtime as a function od input scale may not be able to the linear pattern.
Plot of runtime as a function of input scale for question4:



Question 5:

Python code is a separate file.

In this question, 3 sum problem could be solved within order n^2. Here, a simple for loop will iterate through the array and in each array, a linear search function will find all pairs that have 3-sum with the outer loop number. This solution asks the array to be sorted ahead of time. So, time of sorting is not included in run time. In plot, since we don't have big enough test inputs, we can only roughly tell the quadratic pattern.

Plot of run time as a function of input number: