**SelectionSort**

| InputSize| Time1 | Time2 | Time3 | Time4 | Time5 | Time6 | Time7 | Time8 | Time9 | Time10| Avg Time|

|====================================================================================================|

| 10000 | 45 | 38 | 35 | 35 | 34 | 35 | 34 | 34 | 34 | 33 | 35.7 |

| 20000 | 163 | 159 | 162 | 163 | 176 | 136 | 132 | 134 | 137 | 137 | 149.9 |

| 30000 | 371 | 321 | 400 | 330 | 374 | 353 | 300 | 304 | 340 | 369 | 346.2 |

| 40000 | 627 | 549 | 559 | 533 | 602 | 536 | 566 | 540 | 537 | 545 | 559.4 |

| 50000 | 848 | 896 | 904 | 888 | 845 | 854 | 856 | 930 | 847 | 858 | 872.6 |

| 60000 | 1392 | 1303 | 1358 | 1268 | 1460 | 1391 | 1298 | 1333 | 1294 | 1320 | 1341.7 |

| 70000 | 1747 | 1947 | 1942 | 1930 | 1999 | 1822 | 1815 | 1831 | 1799 | 1728 | 1856.0 |

| 80000 | 2344 | 2272 | 2242 | 2186 | 2331 | 2283 | 2459 | 2281 | 2476 | 2351 | 2322.5 |

| 90000 | 2864 | 3242 | 3532 | 2878 | 2770 | 2847 | 2801 | 3030 | 3110 | 3077 | 3015.1 |

| 100000 | 4140 | 3560 | 3572 | 3405 | 3459 | 3426 | 3527 | 3466 | 3485 | 3557 | 3559.7 |

| 110000 | 4714 | 5054 | 5912 | 6046 | 4800 | 4405 | 4453 | 4598 | 4507 | 4487 | 4897.6 |

| 120000 | 5160 | 5139 | 5592 | 5017 | 5283 | 5790 | 5173 | 5175 | 5225 | 5194 | 5274.8 |

| 130000 | 6092 | 6929 | 7147 | 7252 | 6113 | 6068 | 6796 | 7302 | 7552 | 6479 | 6773.0 |

| 140000 | 7137 | 7366 | 7219 | 7500 | 7938 | 7495 | 7154 | 7713 | 6936 | 7098 | 7355.6 |

| 150000 | 8006 | 8403 | 8360 | 8095 | 7933 | 8006 | 8372 | 8039 | 8220 | 7989 | 8142.3 |

| 160000 | 9174 | 9082 | 9416 | 9148 | 8841 | 9608 | 9844 | 9803 | 9352 | 9149 | 9341.7 |

| 170000 | 10704 | 10360 | 10455 | 10239 | 10327 | 10302 | 10227 | 10285 | 10366 | 10327 | 10359.2 |

| 180000 | 11618 | 11502 | 11422 | 11794 | 11733 | 11519 | 11387 | 11431 | 11479 | 11203 | 11508.8 |

| 190000 | 12715 | 12834 | 12769 | 12850 | 12809 | 12641 | 13112 | 13563 | 13819 | 13054 | 13016.6 |

| 200000 | 14852 | 15150 | 15163 | 14727 | 15140 | 14931 | 14337 | 15567 | 15240 | 14660 | 14976.7 |

| 210000 | 17052 | 16677 | 16654 | 17039 | 16823 | 16594 | 17195 | 16330 | 17147 | 16725 | 16823.6 |

| 220000 | 19133 | 18237 | 18387 | 19198 | 17310 | 17105 | 17335 | 17051 | 17333 | 17394 | 17848.3 |

| 230000 | 18693 | 19474 | 19242 | 18923 | 18926 | 18503 | 18528 | 18846 | 18761 | 18864 | 18876.0 |

| 240000 | 20318 | 20196 | 20963 | 23723 | 20026 | 19858 | 19689 | 19481 | 19521 | 19578 | 20335.3 |

| 250000 | 21230 | 21182 | 21099 | 21160 | 21317 | 21210 | 21131 | 21184 | 21638 | 21166 | 21231.7 |

| 260000 | 23217 | 23084 | 23179 | 22853 | 22959 | 22869 | 22904 | 22909 | 22947 | 22868 | 22978.9 |

| 270000 | 24746 | 24775 | 24904 | 24926 | 24677 | 24671 | 24632 | 24791 | 24809 | 24624 | 24755.5 |

| 280000 | 26518 | 26535 | 26670 | 26566 | 26497 | 26496 | 26502 | 26489 | 26464 | 26514 | 26525.1 |

| 290000 | 28508 | 28531 | 28446 | 28458 | 28425 | 28809 | 28495 | 28367 | 28345 | 28433 | 28481.7 |

| 300000 | 30524 | 32436 | 33297 | 31793 | 31211 | 32069 | 30771 | 30657 | 31647 | 31795 | 31620.0 |

| 310000 | 34582 | 34008 | 34307 | 32441 | 32296 | 33411 | 33464 | 35123 | 33128 | 34807 | 33756.7 |

| 320000 | 36671 | 37824 | 35757 | 37676 | 40544 | 34922 | 35939 | 39449 | 37582 | 36138 | 37250.2 |

| 330000 | 39938 | 37179 | 38936 | 40456 | 48335 | 45960 | 37821 | 37587 | 40068 | 42460 | 40874.0 |

| 340000 | 43192 | 45198 | 41675 | 43744 | 40373 | 42405 | 43028 | 44141 | 44726 | 43583 | 43206.5 |

| 350000 | 46071 | 44810 | 45725 | 49568 | 48190 | 45758 | 42727 | 44246 | 43540 | 43240 | 45387.5 |

| 360000 | 49297 | 45167 | 45826 | 46089 | 46916 | 46416 | 45222 | 46114 | 46730 | 49282 | 46705.9 |

| 370000 | 55154 | 49488 | 48854 | 49106 | 47962 | 49040 | 49049 | 48419 | 55336 | 48869 | 50127.7 |

| 380000 | 52821 | 52554 | 52053 | 52384 | 54281 | 52497 | 55615 | 53298 | 51948 | 52450 | 52990.1 |

| 390000 | 53984 | 56919 | 60650 | 54559 | 54491 | 54826 | 54909 | 53570 | 54623 | 54372 | 55290.3 |

| 400000 | 56586 | 56560 | 56574 | 56978 | 57020 | 57130 | 57782 | 56249 | 57568 | 57090 | 56953.7 |

| 410000 | 60590 | 59837 | 60409 | 59550 | 60253 | 63486 | 66595 | 70434 | 67949 | 65960 | 63506.3 |

| 420000 | 65634 | 72931 | 63920 | 66514 | 64120 | 64282 | 63201 | 65439 | 64642 | 63743 | 65442.6 |

| 430000 | 67840 | 69349 | 72468 | 72609 | 73103 | 70636 | 67507 | 71488 | 85181 | 72461 | 72264.2 |

| 440000 | 71076 | 77708 | 78711 | 73285 | 88766 | 84463 | 71381 | 75415 | 73111 | 72457 | 76637.3 |

| 450000 | 74017 | 75318 | 76696 | 77382 | 77398 | 76653 | 78277 | 75613 | 74815 | 74104 | 76027.3 |

| 460000 | 74678 | 74376 | 81194 | 78884 | 76013 | 76553 | 80617 | 74867 | 78433 | 81489 | 77710.4 |

| 470000 | 91763 | 99328 | 90713 | 101553| 95017 | 113482| 114487| 112030| 113741| 116009| 104812.3|

| 480000 | 116264| 103148| 97784 | 96856 | 102367| 98022 | 101052| 102098| 97892 | 103311| 101879.4|

| 490000 | 104237| 107954| 104213| 107146| 107423| 103912| 106826| 108046| 112886| 108499| 107114.2|

| 500000 | 107311| 104951| 107136| 112993| 118054| 109509| 110435| 116160| 117194| 115497| 111924.0|

**Determining Constant**

**N T(N) N^2 T(N)/N^2**

|  |  |  |  |
| --- | --- | --- | --- |
| 10000 | 35.7 | 1E+08 | 0.000000357 |
| 20000 | 149.9 | 4E+08 | 3.7475E-07 |
| 30000 | 346.2 | 9E+08 | 3.84667E-07 |
| 40000 | 559.4 | 2E+09 | 3.49625E-07 |
| 50000 | 872.6 | 3E+09 | 3.4904E-07 |
| 60000 | 1341.7 | 4E+09 | 3.72694E-07 |
| 70000 | 1856 | 5E+09 | 3.78776E-07 |
| 80000 | 2322.5 | 6E+09 | 3.62891E-07 |
| 90000 | 3015.1 | 8E+09 | 3.72235E-07 |
| 100000 | 3559.7 | 1E+10 | 3.5597E-07 |
| 110000 | 4897.6 | 1E+10 | 4.0476E-07 |
| 120000 | 5274.8 | 1E+10 | 3.66306E-07 |
| 130000 | 6773 | 2E+10 | 4.00769E-07 |
| 140000 | 7355.6 | 2E+10 | 3.75286E-07 |
| 150000 | 8142.3 | 2E+10 | 3.6188E-07 |
| 160000 | 9341.7 | 3E+10 | 3.6491E-07 |
| 170000 | 10359 | 3E+10 | 3.5845E-07 |
| 180000 | 11509 | 3E+10 | 3.5521E-07 |
| 190000 | 13017 | 4E+10 | 3.60571E-07 |
| 200000 | 14977 | 4E+10 | 3.74418E-07 |
| 210000 | 16824 | 4E+10 | 3.81488E-07 |
| 220000 | 17848 | 5E+10 | 3.68767E-07 |
| 230000 | 18876 | 5E+10 | 3.56824E-07 |
| 240000 | 20335 | 6E+10 | 3.53043E-07 |
| 250000 | 21232 | 6E+10 | 3.39707E-07 |
| 260000 | 22979 | 7E+10 | 3.39925E-07 |
| 270000 | 24756 | 7E+10 | 3.39582E-07 |
| 280000 | 26525 | 8E+10 | 3.3833E-07 |
| 290000 | 28482 | 8E+10 | 3.38665E-07 |
| 300000 | 31620 | 9E+10 | 3.51333E-07 |
| 310000 | 33757 | 1E+11 | 3.51266E-07 |
| 320000 | 37250 | 1E+11 | 3.63771E-07 |
| 330000 | 40874 | 1E+11 | 3.75335E-07 |
| 340000 | 43207 | 1E+11 | 3.73759E-07 |
| 350000 | 45388 | 1E+11 | 3.7051E-07 |
| 360000 | 46706 | 1E+11 | 3.60385E-07 |
| 370000 | 50128 | 1E+11 | 3.66163E-07 |
| 380000 | 52990 | 1E+11 | 3.66967E-07 |
| 390000 | 55290 | 2E+11 | 3.63513E-07 |
| 400000 | 56954 | 2E+11 | 3.55961E-07 |
| 410000 | 63506 | 2E+11 | 3.77789E-07 |
| 420000 | 65443 | 2E+11 | 3.7099E-07 |
| 430000 | 72264 | 2E+11 | 3.90829E-07 |
| 440000 | 76637 | 2E+11 | 3.95854E-07 |
| 450000 | 76027 | 2E+11 | 3.75443E-07 |
| 460000 | 77710 | 2E+11 | 3.67251E-07 |
| 470000 | 104812 | 2E+11 | 4.74478E-07 |
| 480000 | 101879 | 2E+11 | 4.42185E-07 |
| 490000 | 107114 | 2E+11 | 4.46123E-07 |
| 500000 | 111924 | 3E+11 | 4.47696E-07 |
|  |  |  | 3.72483E-07 |

**Mathematical Analysis**

Size of input = N

Total No of exchanges = (N-1) + (N-2) + (N-3) +…………+1=(N-1)(N-2)/2 ~ N^2/2

Total No of compares = N

Total Time = K(N^2/2 + N) = O(N^2)

Determining constant value

Randomized Input

Space Complexity = O(1)

This is an unstable and inplace sorting algorithm.

Initial Order- Selection sort run time does not depend on initial order of the input.

Best case runtime = Worst case runtime = Average case runtimeO(n^2)

K = T(N)/N^2 = 3.72483E-07

**InsertionSort**

| InputSize| Time1| Time2| Time3| Time4| Time5| Time6| Time7| Time8| Time9| Time10| Avg Time|

|===========================================================================================|

| 10000 | 56 | 46 | 59 | 55 | 52 | 49 | 56 | 54 | 54 | 56 | 53.7 |

| 20000 | 224 | 214 | 219 | 220 | 210 | 215 | 219 | 212 | 212 | 216 | 216.1 |

| 30000 | 482 | 480 | 486 | 471 | 487 | 475 | 479 | 478 | 502 | 477 | 481.7 |

| 40000 | 843 | 856 | 849 | 856 | 881 | 864 | 854 | 866 | 848 | 851 | 856.8 |

| 50000 | 1324 | 1323 | 1327 | 1332 | 1292 | 1355 | 1338 | 1339 | 1338 | 1346 | 1331.4 |

| 60000 | 1948 | 2023 | 2027 | 1979 | 1979 | 1933 | 1947 | 1941 | 1932 | 1916 | 1962.5 |

| 70000 | 2646 | 2676 | 2677 | 2657 | 2576 | 2585 | 2691 | 2619 | 2723 | 2790 | 2664.0 |

| 80000 | 3997 | 3525 | 3987 | 3565 | 3634 | 3491 | 3549 | 3527 | 3541 | 3602 | 3641.8 |

| 90000 | 4697 | 4528 | 4443 | 4523 | 4740 | 4526 | 4448 | 4599 | 4559 | 4514 | 4557.7 |

| 100000 | 5535 | 5531 | 5445 | 5382 | 5413 | 5938 | 5474 | 5393 | 5610 | 5406 | 5512.7 |

| 110000 | 6781 | 7049 | 6499 | 6475 | 6496 | 6533 | 6492 | 6962 | 6652 | 6494 | 6643.3 |

| 120000 | 7797 | 7729 | 7726 | 8054 | 8489 | 7785 | 7702 | 7702 | 7867 | 8384 | 7923.5 |

| 130000 | 9843 | 9992 | 9370 | 10028| 9183 | 9258 | 8970 | 9069 | 8981 | 9001 | 9369.5 |

| 140000 | 10496| 10402| 10537| 10667| 11391| 11222| 11503| 11192| 11135| 10387 | 10893.2 |

| 150000 | 12118| 12102| 12598| 12646| 12901| 12226| 12298| 12467| 12231| 12148 | 12373.5 |

Sorted Input

| InputSize| Time1| Time2| Time3| Time4| Time5| Time6| Time7| Time8| Time9| Time10| Avg Time|

|===========================================================================================|

| 10000 | 3 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1.2 |

| 20000 | 3 | 9 | 3 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2.9 |

| 30000 | 5 | 5 | 5 | 5 | 3 | 3 | 5 | 5 | 3 | 4 | 4.3 |

| 40000 | 5 | 5 | 6 | 5 | 5 | 7 | 7 | 5 | 5 | 6 | 5.6 |

| 50000 | 6 | 8 | 7 | 7 | 9 | 7 | 6 | 7 | 6 | 7 | 7.0 |

| 60000 | 11 | 9 | 9 | 9 | 8 | 9 | 10 | 12 | 11 | 8 | 9.6 |

| 70000 | 10 | 10 | 9 | 9 | 9 | 9 | 10 | 9 | 10 | 10 | 9.5 |

| 80000 | 12 | 11 | 11 | 14 | 12 | 13 | 13 | 11 | 15 | 11 | 12.3 |

| 90000 | 13 | 13 | 15 | 16 | 16 | 13 | 14 | 15 | 14 | 17 | 14.6 |

| 100000 | 16 | 16 | 21 | 16 | 18 | 17 | 19 | 19 | 15 | 14 | 17.1 |

| 110000 | 17 | 19 | 17 | 16 | 17 | 17 | 19 | 17 | 22 | 18 | 17.9 |

| 120000 | 22 | 21 | 20 | 24 | 20 | 19 | 18 | 19 | 20 | 18 | 20.1 |

| 130000 | 25 | 20 | 25 | 24 | 26 | 19 | 26 | 21 | 23 | 19 | 22.8 |

| 140000 | 21 | 24 | 21 | 27 | 22 | 23 | 26 | 24 | 22 | 22 | 23.2 |

| 150000 | 24 | 24 | 26 | 26 | 23 | 28 | 26 | 24 | 24 | 22 | 24.7 |

| 160000 | 29 | 28 | 30 | 25 | 28 | 28 | 31 | 29 | 26 | 29 | 28.3 |

| 170000 | 31 | 29 | 29 | 29 | 34 | 29 | 29 | 27 | 29 | 30 | 29.6 |

| 180000 | 34 | 27 | 34 | 34 | 35 | 34 | 28 | 32 | 28 | 32 | 31.8 |

| 190000 | 37 | 31 | 37 | 32 | 35 | 37 | 35 | 38 | 35 | 32 | 34.9 |

| 200000 | 38 | 38 | 39 | 35 | 32 | 35 | 33 | 31 | 36 | 41 | 35.8 |

| 210000 | 35 | 40 | 40 | 36 | 34 | 40 | 34 | 37 | 43 | 38 | 37.7 |

| 220000 | 43 | 41 | 42 | 40 | 47 | 44 | 43 | 44 | 38 | 38 | 42.0 |

| 230000 | 39 | 40 | 44 | 46 | 49 | 50 | 49 | 45 | 48 | 51 | 46.1 |

| 240000 | 47 | 50 | 50 | 52 | 47 | 50 | 49 | 51 | 47 | 43 | 48.6 |

| 250000 | 48 | 47 | 47 | 46 | 52 | 49 | 46 | 40 | 46 | 45 | 46.6 |

| 260000 | 55 | 56 | 45 | 50 | 47 | 48 | 45 | 49 | 53 | 50 | 49.8 |

| 270000 | 45 | 51 | 45 | 58 | 48 | 52 | 49 | 56 | 49 | 50 | 50.3 |

| 280000 | 54 | 50 | 49 | 55 | 51 | 52 | 52 | 54 | 56 | 54 | 52.7 |

| 290000 | 53 | 59 | 53 | 57 | 59 | 54 | 58 | 56 | 63 | 51 | 56.3 |

| 300000 | 53 | 52 | 54 | 66 | 54 | 59 | 58 | 58 | 52 | 62 | 56.8 |

| 310000 | 58 | 57 | 55 | 60 | 56 | 58 | 55 | 58 | 54 | 60 | 57.1 |

| 320000 | 55 | 60 | 58 | 61 | 62 | 63 | 63 | 66 | 59 | 58 | 60.5 |

| 330000 | 60 | 69 | 71 | 62 | 70 | 63 | 59 | 67 | 59 | 59 | 63.9 |

| 340000 | 62 | 71 | 66 | 67 | 70 | 68 | 62 | 72 | 65 | 72 | 67.5 |

| 350000 | 71 | 73 | 76 | 70 | 74 | 70 | 73 | 68 | 68 | 72 | 71.5 |

| 360000 | 70 | 74 | 74 | 71 | 68 | 73 | 78 | 85 | 85 | 69 | 74.7 |

| 370000 | 78 | 73 | 84 | 76 | 70 | 74 | 71 | 74 | 79 | 80 | 75.9 |

| 380000 | 77 | 77 | 80 | 74 | 82 | 74 | 77 | 83 | 71 | 78 | 77.3 |

| 390000 | 80 | 86 | 93 | 80 | 81 | 77 | 89 | 84 | 82 | 88 | 84.0 |

| 400000 | 82 | 92 | 93 | 88 | 81 | 87 | 81 | 82 | 87 | 80 | 85.3 |

| 410000 | 79 | 80 | 91 | 88 | 86 | 86 | 83 | 87 | 80 | 89 | 84.9 |

| 420000 | 89 | 90 | 94 | 79 | 85 | 87 | 87 | 86 | 87 | 85 | 86.9 |

| 430000 | 90 | 90 | 102 | 98 | 90 | 88 | 90 | 90 | 92 | 90 | 92.0 |

| 440000 | 98 | 99 | 104 | 88 | 92 | 99 | 92 | 91 | 94 | 91 | 94.8 |

| 450000 | 100 | 101 | 106 | 94 | 105 | 94 | 92 | 96 | 85 | 98 | 97.1 |

| 460000 | 105 | 105 | 105 | 100 | 105 | 103 | 93 | 101 | 94 | 102 | 101.3 |

| 470000 | 99 | 103 | 111 | 112 | 109 | 108 | 96 | 98 | 104 | 100 | 104.0 |

| 480000 | 106 | 115 | 107 | 110 | 104 | 101 | 110 | 110 | 108 | 105 | 107.6 |

| 490000 | 105 | 121 | 134 | 135 | 132 | 133 | 124 | 121 | 126 | 120 | 125.1 |

| 500000 | 112 | 140 | 120 | 110 | 112 | 114 | 109 | 109 | 111 | 115 | 115.2 |

| 510000 | 114 | 121 | 171 | 120 | 113 | 112 | 120 | 116 | 110 | 117 | 121.4 |

| 520000 | 121 | 129 | 122 | 123 | 116 | 117 | 124 | 124 | 118 | 121 | 121.5 |

| 530000 | 123 | 126 | 121 | 128 | 127 | 109 | 115 | 125 | 117 | 165 | 125.6 |

| 540000 | 131 | 122 | 130 | 117 | 125 | 179 | 139 | 123 | 129 | 132 | 132.7 |

| 550000 | 145 | 179 | 133 | 122 | 143 | 164 | 123 | 133 | 117 | 181 | 144.0 |

| 560000 | 134 | 143 | 140 | 154 | 158 | 144 | 136 | 140 | 146 | 167 | 146.2 |

| 570000 | 135 | 144 | 144 | 187 | 137 | 125 | 179 | 135 | 133 | 126 | 144.5 |

| 580000 | 127 | 189 | 138 | 135 | 131 | 128 | 132 | 177 | 131 | 135 | 142.3 |

| 590000 | 140 | 148 | 134 | 144 | 142 | 144 | 150 | 142 | 151 | 135 | 143.0 |

| 600000 | 150 | 167 | 181 | 144 | 141 | 141 | 160 | 175 | 166 | 159 | 158.4 |

| 610000 | 146 | 155 | 320 | 228 | 310 | 331 | 317 | 229 | 201 | 195 | 243.2 |

| 620000 | 153 | 148 | 164 | 173 | 148 | 156 | 211 | 202 | 210 | 249 | 181.4 |

| 630000 | 312 | 336 | 241 | 241 | 224 | 156 | 156 | 156 | 154 | 158 | 213.4 |

| 640000 | 153 | 172 | 150 | 167 | 168 | 145 | 164 | 178 | 151 | 137 | 158.5 |

| 650000 | 147 | 160 | 158 | 142 | 151 | 181 | 195 | 159 | 175 | 270 | 173.8 |

| 660000 | 226 | 209 | 173 | 187 | 165 | 167 | 185 | 184 | 178 | 183 | 185.7 |

| 670000 | 212 | 184 | 151 | 157 | 150 | 153 | 159 | 165 | 148 | 164 | 164.3 |

| 680000 | 170 | 149 | 163 | 158 | 163 | 176 | 153 | 157 | 152 | 147 | 158.8 |

| 690000 | 167 | 176 | 167 | 173 | 182 | 166 | 164 | 175 | 151 | 153 | 167.4 |

| 700000 | 158 | 156 | 158 | 161 | 163 | 166 | 180 | 160 | 169 | 175 | 164.6 |

| 710000 | 166 | 206 | 193 | 174 | 189 | 182 | 181 | 176 | 191 | 179 | 183.7 |

| 720000 | 279 | 185 | 165 | 185 | 160 | 171 | 173 | 176 | 184 | 164 | 184.2 |

| 730000 | 174 | 184 | 180 | 172 | 185 | 175 | 180 | 181 | 185 | 187 | 180.3 |

| 740000 | 172 | 201 | 168 | 185 | 174 | 181 | 161 | 164 | 173 | 170 | 174.9 |

| 750000 | 172 | 190 | 167 | 166 | 173 | 175 | 177 | 159 | 181 | 178 | 173.8 |

**Insertion Sort(random input)**

**Sorted Input**

**Determining Constant**

|  |  |  |  |
| --- | --- | --- | --- |
| 10000 | 53.7 | 1E+08 | 0.000000537 |
| 20000 | 216.1 | 4E+08 | 5.4025E-07 |
| 30000 | 481.7 | 9E+08 | 5.35222E-07 |
| 40000 | 856 | 1.6E+09 | 0.000000535 |
| 50000 | 1331 | 2.5E+09 | 5.324E-07 |
| 60000 | 1962 | 3.6E+09 | 0.000000545 |
| 70000 | 2664 | 4.9E+09 | 5.43673E-07 |
| 80000 | 3641 | 6.4E+09 | 5.68906E-07 |
| 90000 | 4557 | 8.1E+09 | 5.62593E-07 |
| 100000 | 5512 | 1E+10 | 5.512E-07 |
| 110000 | 6643 | 1.21E+10 | 5.49008E-07 |
| 120000 | 7923 | 1.44E+10 | 5.50208E-07 |
| 130000 | 9369 | 1.69E+10 | 5.54379E-07 |
| 140000 | 10893 | 1.96E+10 | 5.55765E-07 |
| 150000 | 12373 | 2.25E+10 | 5.49911E-07 |
|  |  |  | 5.47368E-07 |

Constant k = T(N)/N^2 = 5.47368E-07

**Mathematical Analysis**

Size Of Input = N

Total No of swaps will always be lesser than or equal to total no of compares depending on input order.

Worst Case

Total no of compares = N + (N-1) + (N-2) + ………+ 1 ~N^2/2

Total no of exchanges = Total no of compares = N^2/2

Total Time = K(N^2/2 + N^2/2) = KN^2 = O(N^2)

**Best Case**

Total no of compares = N-1

Total no of exchanges = 0

Total Time = K(N-1) = O(N)

**Average Case**

Total no of compares = N^2/4

Total no of exchanges = N^2/4

Total Time = K(N^2/4 + N^2/4) = O(N^2/2)

Space Complexity = O(1)

This is an stable and inplace sorting algorithm.

Initial Order- Insertion sort run time does depend on initial order of the input.For sorted input its runtime is O(N).Otherwise worst case runtime equals average case runtime

**MergeSort**

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

| InputSize| Time1| Time2| Time3| Time4| Time5| Time6| Time7| Time8| Time9| Time10| Avg Time|

|===========================================================================================|

| 10000 | 3 | 5 | 1 | 1 | 1 | 1 | 1 | 1 | 2 | 1 | 1.7 |

| 20000 | 2 | 2 | 3 | 2 | 2 | 2 | 2 | 2 | 4 | 2 | 2.3 |

| 30000 | 4 | 3 | 4 | 4 | 3 | 3 | 3 | 3 | 3 | 3 | 3.3 |

| 40000 | 5 | 5 | 5 | 4 | 4 | 4 | 4 | 4 | 4 | 6 | 4.5 |

| 50000 | 6 | 7 | 7 | 7 | 6 | 7 | 5 | 5 | 5 | 6 | 6.1 |

| 60000 | 6 | 6 | 9 | 6 | 6 | 9 | 9 | 9 | 7 | 6 | 7.3 |

| 70000 | 8 | 7 | 8 | 8 | 7 | 8 | 7 | 7 | 7 | 9 | 7.6 |

| 80000 | 9 | 8 | 9 | 9 | 11 | 12 | 9 | 9 | 11 | 9 | 9.6 |

| 90000 | 10 | 10 | 12 | 10 | 13 | 13 | 10 | 10 | 10 | 13 | 11.1 |

| 100000 | 11 | 11 | 13 | 11 | 12 | 13 | 13 | 11 | 12 | 13 | 12.0 |

| 110000 | 12 | 12 | 12 | 12 | 12 | 14 | 15 | 14 | 17 | 12 | 13.2 |

| 120000 | 15 | 18 | 14 | 14 | 16 | 15 | 15 | 17 | 13 | 14 | 15.1 |

| 130000 | 14 | 14 | 19 | 16 | 15 | 16 | 16 | 18 | 20 | 15 | 16.3 |

| 140000 | 17 | 19 | 22 | 21 | 16 | 20 | 16 | 20 | 19 | 18 | 18.8 |

| 150000 | 19 | 19 | 20 | 19 | 19 | 17 | 19 | 20 | 17 | 20 | 18.9 |

| 160000 | 21 | 22 | 19 | 19 | 23 | 18 | 22 | 22 | 19 | 20 | 20.5 |

| 170000 | 21 | 22 | 24 | 23 | 24 | 22 | 20 | 20 | 24 | 22 | 22.2 |

| 180000 | 22 | 29 | 25 | 24 | 23 | 21 | 21 | 24 | 21 | 26 | 23.6 |

| 190000 | 27 | 29 | 24 | 25 | 26 | 25 | 26 | 27 | 26 | 29 | 26.4 |

| 200000 | 26 | 24 | 28 | 31 | 28 | 28 | 27 | 26 | 25 | 31 | 27.4 |

| 210000 | 34 | 28 | 27 | 29 | 29 | 30 | 30 | 30 | 33 | 31 | 30.1 |

| 220000 | 34 | 29 | 27 | 28 | 30 | 30 | 31 | 31 | 33 | 31 | 30.4 |

| 230000 | 32 | 32 | 32 | 31 | 33 | 34 | 29 | 30 | 36 | 29 | 31.8 |

| 240000 | 35 | 34 | 35 | 33 | 35 | 34 | 36 | 33 | 32 | 33 | 34.0 |

| 250000 | 39 | 32 | 31 | 35 | 33 | 36 | 35 | 39 | 37 | 35 | 35.2 |

| 260000 | 38 | 39 | 37 | 37 | 39 | 37 | 37 | 34 | 39 | 40 | 37.7 |

| 270000 | 40 | 41 | 39 | 40 | 42 | 54 | 52 | 45 | 41 | 41 | 43.5 |

| 280000 | 43 | 41 | 38 | 37 | 42 | 42 | 39 | 45 | 38 | 35 | 40.0 |

| 290000 | 45 | 44 | 48 | 38 | 45 | 44 | 40 | 39 | 40 | 47 | 43.0 |

| 300000 | 45 | 55 | 47 | 49 | 44 | 43 | 43 | 46 | 41 | 45 | 45.8 |

| 310000 | 43 | 41 | 43 | 45 | 40 | 49 | 44 | 43 | 42 | 46 | 43.6 |

| 320000 | 44 | 45 | 41 | 44 | 40 | 46 | 41 | 47 | 53 | 49 | 45.0 |

| 330000 | 47 | 46 | 50 | 43 | 44 | 41 | 50 | 49 | 42 | 45 | 45.7 |

| 340000 | 47 | 48 | 49 | 46 | 49 | 46 | 47 | 51 | 51 | 46 | 48.0 |

| 350000 | 53 | 44 | 51 | 49 | 54 | 49 | 47 | 45 | 48 | 49 | 48.9 |

| 360000 | 47 | 56 | 60 | 58 | 63 | 57 | 56 | 47 | 47 | 52 | 54.3 |

| 370000 | 55 | 52 | 53 | 53 | 54 | 52 | 54 | 60 | 57 | 48 | 53.8 |

| 380000 | 56 | 51 | 53 | 58 | 50 | 51 | 51 | 56 | 52 | 53 | 53.1 |

| 390000 | 53 | 53 | 54 | 52 | 50 | 54 | 51 | 49 | 53 | 49 | 51.8 |

| 400000 | 51 | 54 | 64 | 51 | 59 | 56 | 55 | 51 | 54 | 55 | 55.0 |

| 410000 | 54 | 55 | 54 | 60 | 59 | 56 | 61 | 56 | 54 | 61 | 57.0 |

| 420000 | 60 | 62 | 62 | 70 | 54 | 61 | 62 | 57 | 65 | 64 | 61.7 |

| 430000 | 58 | 61 | 66 | 62 | 59 | 67 | 63 | 65 | 63 | 63 | 62.7 |

| 440000 | 60 | 64 | 67 | 60 | 67 | 66 | 64 | 65 | 62 | 60 | 63.5 |

| 450000 | 62 | 62 | 60 | 62 | 63 | 62 | 64 | 67 | 63 | 61 | 62.6 |

| 460000 | 73 | 70 | 69 | 66 | 65 | 66 | 73 | 67 | 66 | 63 | 67.8 |

| 470000 | 72 | 76 | 78 | 73 | 71 | 65 | 69 | 71 | 64 | 72 | 71.1 |

| 480000 | 70 | 71 | 73 | 72 | 64 | 72 | 68 | 67 | 70 | 70 | 69.7 |

| 490000 | 72 | 65 | 65 | 64 | 63 | 65 | 75 | 66 | 67 | 68 | 67.0 |

| 500000 | 78 | 69 | 64 | 66 | 75 | 74 | 79 | 67 | 69 | 70 | 71.1 |

| 510000 | 74 | 72 | 75 | 72 | 70 | 69 | 75 | 69 | 74 | 74 | 72.4 |

| 520000 | 73 | 76 | 74 | 79 | 75 | 72 | 72 | 80 | 83 | 68 | 75.2 |

| 530000 | 85 | 72 | 73 | 75 | 72 | 73 | 74 | 79 | 79 | 77 | 75.9 |

| 540000 | 80 | 74 | 74 | 73 | 71 | 81 | 78 | 75 | 80 | 73 | 75.9 |

| 550000 | 79 | 81 | 79 | 76 | 77 | 81 | 76 | 80 | 76 | 85 | 79.0 |

| 560000 | 83 | 89 | 85 | 84 | 74 | 77 | 86 | 77 | 87 | 83 | 82.5 |

| 570000 | 82 | 90 | 91 | 81 | 83 | 89 | 83 | 89 | 85 | 93 | 86.6 |

| 580000 | 85 | 80 | 85 | 84 | 91 | 79 | 89 | 80 | 77 | 83 | 83.3 |

| 590000 | 77 | 79 | 83 | 83 | 84 | 88 | 81 | 86 | 83 | 91 | 83.5 |

| 600000 | 92 | 89 | 96 | 87 | 91 | 82 | 93 | 88 | 94 | 104 | 91.6 |

| 610000 | 89 | 95 | 90 | 90 | 86 | 88 | 89 | 90 | 85 | 92 | 89.4 |

| 620000 | 94 | 98 | 94 | 95 | 94 | 95 | 94 | 86 | 87 | 104 | 94.1 |

| 630000 | 92 | 97 | 88 | 100 | 90 | 94 | 86 | 92 | 92 | 96 | 92.7 |

| 640000 | 86 | 100 | 97 | 96 | 102 | 104 | 101 | 88 | 88 | 93 | 95.5 |

| 650000 | 95 | 93 | 99 | 91 | 96 | 94 | 93 | 89 | 99 | 97 | 94.6 |

| 660000 | 97 | 102 | 95 | 92 | 100 | 88 | 90 | 103 | 96 | 93 | 95.6 |

| 670000 | 96 | 93 | 104 | 100 | 94 | 93 | 105 | 93 | 100 | 97 | 97.5 |

| 680000 | 95 | 94 | 98 | 98 | 93 | 109 | 106 | 96 | 99 | 105 | 99.3 |

| 690000 | 94 | 109 | 107 | 101 | 98 | 105 | 96 | 102 | 109 | 101 | 102.2 |

| 700000 | 96 | 100 | 101 | 96 | 102 | 95 | 112 | 97 | 101 | 99 | 99.9 |

| 710000 | 104 | 103 | 105 | 114 | 111 | 109 | 103 | 104 | 116 | 117 | 108.6 |

| 720000 | 115 | 108 | 105 | 120 | 106 | 105 | 111 | 116 | 112 | 109 | 110.7 |

| 730000 | 109 | 104 | 109 | 108 | 106 | 117 | 102 | 109 | 104 | 113 | 108.1 |

| 740000 | 112 | 111 | 111 | 113 | 103 | 118 | 108 | 102 | 110 | 110 | 109.8 |

| 750000 | 109 | 114 | 103 | 103 | 111 | 116 | 113 | 108 | 108 | 102 | 108.7 |

| 760000 | 114 | 112 | 108 | 116 | 117 | 108 | 115 | 118 | 112 | 110 | 113.0 |

| 770000 | 112 | 112 | 125 | 108 | 111 | 109 | 112 | 116 | 110 | 116 | 113.1 |

| 780000 | 124 | 108 | 110 | 112 | 114 | 117 | 112 | 115 | 111 | 111 | 113.4 |

| 790000 | 120 | 110 | 112 | 110 | 120 | 111 | 119 | 116 | 107 | 114 | 113.9 |

| 800000 | 118 | 120 | 116 | 117 | 134 | 119 | 116 | 117 | 115 | 123 | 119.5 |

| 810000 | 119 | 118 | 115 | 118 | 128 | 124 | 121 | 111 | 114 | 114 | 118.2 |

| 820000 | 118 | 122 | 120 | 121 | 125 | 125 | 116 | 131 | 119 | 124 | 122.1 |

| 830000 | 130 | 132 | 141 | 121 | 116 | 122 | 127 | 118 | 124 | 118 | 124.9 |

| 840000 | 129 | 131 | 123 | 122 | 119 | 128 | 121 | 138 | 132 | 123 | 126.6 |

| 850000 | 124 | 124 | 122 | 125 | 118 | 126 | 131 | 124 | 118 | 125 | 123.7 |

| 860000 | 140 | 123 | 132 | 128 | 125 | 125 | 120 | 122 | 126 | 132 | 127.3 |

| 870000 | 138 | 136 | 137 | 125 | 122 | 131 | 132 | 138 | 134 | 130 | 132.3 |

| 880000 | 129 | 138 | 131 | 128 | 141 | 127 | 134 | 140 | 130 | 123 | 132.1 |

| 890000 | 133 | 131 | 134 | 123 | 133 | 132 | 130 | 139 | 131 | 131 | 131.7 |

| 900000 | 135 | 137 | 125 | 135 | 138 | 131 | 140 | 130 | 130 | 134 | 133.5 |

| 910000 | 139 | 135 | 129 | 140 | 142 | 140 | 134 | 136 | 143 | 137 | 137.5 |

| 920000 | 139 | 134 | 139 | 131 | 141 | 141 | 129 | 125 | 135 | 137 | 135.1 |

| 930000 | 129 | 127 | 146 | 140 | 143 | 140 | 135 | 141 | 127 | 132 | 136.0 |

| 940000 | 156 | 148 | 133 | 133 | 139 | 141 | 143 | 153 | 141 | 141 | 142.8 |

| 950000 | 139 | 136 | 135 | 138 | 130 | 133 | 134 | 140 | 152 | 150 | 138.7 |

| 960000 | 149 | 142 | 146 | 142 | 146 | 151 | 143 | 144 | 144 | 158 | 146.5 |

| 970000 | 157 | 147 | 144 | 151 | 141 | 136 | 153 | 161 | 158 | 146 | 149.4 |

| 980000 | 149 | 140 | 152 | 155 | 159 | 497 | 294 | 173 | 157 | 136 | 201.2 |

| 990000 | 142 | 149 | 142 | 153 | 143 | 149 | 151 | 149 | 140 | 139 | 145.7 |

| 1000000 | 150 | 148 | 147 | 164 | 151 | 145 | 148 | 153 | 148 | 150 | 150.4 |

**Mathematical Analysis**

Total no of compares can be calculated by recurrence C(N) =C(N/2) + C(N/2) + N

Total no of array accesses can also be calculated by recurrence A(N) = A(N/2) + A(N/2) + DN

Each Step takes a time of N with total no of levels equal to lgN.

Therefore total running time = O(NlgN)

The order of input dosen’t matter since Mergesort scans splits and scans through all elements.

Average case running time =Best case running time = worst case running time = O(NlgN)

Merge Sort space complexity is O(N) since an additional auxiliary array is used its space complexity = O(N)

**QuickSort**

**Random input**

**|InputSize|Time1|Time2|Time3|Time4|Time5|Time6|Time7|Time8|Time9|Time10|Avg |**

|===========================================================================================|

| 10000 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.0 |

| 20000 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.1 |

| 30000 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.0 |

| 40000 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.0 |

| 50000 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.0 |

| 60000 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.0 |

| 70000 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 1 | 0.2 |

| 80000 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0.1 |

| 90000 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0.1 |

| 100000 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0.1 |

| 110000 | 0 | 1 | 0 | 1 | 0 | 1 | 1 | 1 | 1 | 0 | 0.6 |

| 120000 | 1 | 1 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0.4 |

| 130000 | 1 | 0 | 1 | 1 | 0 | 1 | 1 | 1 | 0 | 0 | 0.6 |

| 140000 | 1 | 2 | 1 | 0 | 1 | 2 | 2 | 1 | 1 | 0 | 1.1 |

| 150000 | 0 | 0 | 1 | 1 | 0 | 0 | 1 | 0 | 1 | 1 | 0.5 |

| 160000 | 0 | 1 | 2 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 0.5 |

| 170000 | 0 | 0 | 0 | 0 | 1 | 0 | 2 | 0 | 0 | 1 | 0.4 |

| 180000 | 2 | 0 | 1 | 0 | 2 | 1 | 1 | 1 | 1 | 2 | 1.1 |

| 190000 | 0 | 0 | 0 | 0 | 1 | 2 | 1 | 2 | 2 | 1 | 0.9 |

| 200000 | 3 | 2 | 1 | 2 | 1 | 1 | 2 | 2 | 5 | 0 | 1.9 |

| 210000 | 1 | 1 | 1 | 0 | 0 | 0 | 2 | 2 | 0 | 1 | 0.8 |

| 220000 | 1 | 3 | 4 | 4 | 0 | 4 | 3 | 0 | 1 | 0 | 2.0 |

| 230000 | 2 | 2 | 1 | 3 | 2 | 4 | 3 | 2 | 3 | 2 | 2.4 |

| 240000 | 2 | 2 | 1 | 1 | 2 | 3 | 3 | 3 | 3 | 2 | 2.2 |

| 250000 | 4 | 1 | 2 | 3 | 0 | 0 | 0 | 3 | 2 | 0 | 1.5 |

| 260000 | 2 | 4 | 3 | 3 | 2 | 4 | 2 | 0 | 2 | 0 | 2.2 |

| 270000 | 2 | 1 | 3 | 1 | 4 | 4 | 3 | 2 | 2 | 3 | 2.5 |

| 280000 | 4 | 1 | 2 | 3 | 1 | 1 | 2 | 3 | 2 | 1 | 2.0 |

| 290000 | 0 | 1 | 3 | 4 | 1 | 2 | 3 | 4 | 1 | 3 | 2.2 |

| 300000 | 3 | 4 | 3 | 1 | 4 | 4 | 1 | 1 | 1 | 2 | 2.4 |

| 310000 | 4 | 5 | 0 | 2 | 5 | 1 | 5 | 6 | 2 | 4 | 3.4 |

| 320000 | 2 | 3 | 3 | 3 | 3 | 0 | 2 | 3 | 0 | 1 | 2.0 |

| 330000 | 2 | 4 | 5 | 1 | 3 | 1 | 4 | 4 | 5 | 3 | 3.2 |

| 340000 | 5 | 3 | 2 | 6 | 1 | 0 | 3 | 3 | 3 | 3 | 2.9 |

| 350000 | 3 | 2 | 2 | 3 | 4 | 2 | 2 | 3 | 4 | 2 | 2.7 |

| 360000 | 5 | 1 | 4 | 6 | 3 | 4 | 4 | 2 | 4 | 2 | 3.5 |

| 370000 | 5 | 4 | 2 | 4 | 0 | 4 | 5 | 4 | 4 | 1 | 3.3 |

| 380000 | 3 | 5 | 0 | 3 | 5 | 1 | 2 | 4 | 7 | 5 | 3.5 |

| 390000 | 4 | 5 | 5 | 4 | 5 | 4 | 2 | 4 | 4 | 2 | 3.9 |

| 400000 | 6 | 4 | 2 | 5 | 5 | 3 | 3 | 1 | 4 | 2 | 3.5 |

| 410000 | 3 | 7 | 2 | 6 | 4 | 1 | 3 | 5 | 4 | 6 | 4.1 |

| 420000 | 0 | 2 | 4 | 3 | 5 | 4 | 1 | 6 | 3 | 0 | 2.8 |

| 430000 | 6 | 5 | 6 | 5 | 4 | 8 | 2 | 2 | 2 | 2 | 4.2 |

| 440000 | 0 | 4 | 4 | 4 | 5 | 0 | 2 | 4 | 6 | 4 | 3.3 |

| 450000 | 8 | 6 | 3 | 0 | 4 | 1 | 5 | 3 | 3 | 5 | 3.8 |

| 460000 | 7 | 2 | 5 | 5 | 0 | 5 | 7 | 4 | 4 | 3 | 4.2 |

| 470000 | 1 | 5 | 6 | 7 | 4 | 4 | 1 | 11 | 7 | 7 | 5.3 |

| 480000 | 3 | 8 | 6 | 1 | 3 | 3 | 4 | 8 | 0 | 3 | 3.9 |

| 490000 | 2 | 3 | 7 | 6 | 3 | 4 | 8 | 6 | 8 | 0 | 4.7 |

| 500000 | 8 | 4 | 5 | 4 | 8 | 6 | 6 | 8 | 7 | 4 | 6.0 |

| 510000 | 5 | 6 | 8 | 5 | 0 | 6 | 5 | 6 | 5 | 5 | 5.1 |

| 520000 | 5 | 10 | 7 | 7 | 4 | 3 | 4 | 10 | 1 | 2 | 5.3 |

| 530000 | 8 | 3 | 6 | 8 | 6 | 3 | 7 | 4 | 4 | 0 | 4.9 |

| 540000 | 6 | 1 | 7 | 9 | 4 | 7 | 5 | 4 | 8 | 5 | 5.6 |

| 550000 | 0 | 4 | 4 | 7 | 7 | 8 | 1 | 5 | 4 | 0 | 4.0 |

| 560000 | 2 | 5 | 10 | 7 | 2 | 8 | 9 | 3 | 5 | 5 | 5.6 |

| 570000 | 7 | 9 | 8 | 3 | 3 | 5 | 6 | 5 | 1 | 7 | 5.4 |

| 580000 | 7 | 3 | 9 | 7 | 5 | 4 | 1 | 7 | 7 | 6 | 5.6 |

| 590000 | 3 | 2 | 4 | 7 | 9 | 2 | 10 | 3 | 6 | 8 | 5.4 |

| 600000 | 9 | 3 | 10 | 6 | 8 | 5 | 5 | 7 | 5 | 2 | 6.0 |

| 610000 | 1 | 7 | 1 | 8 | 7 | 5 | 9 | 1 | 6 | 5 | 5.0 |

| 620000 | 7 | 3 | 9 | 8 | 9 | 8 | 8 | 9 | 5 | 10 | 7.6 |

| 630000 | 6 | 5 | 6 | 4 | 5 | 6 | 0 | 5 | 2 | 3 | 4.2 |

| 640000 | 3 | 5 | 1 | 1 | 4 | 8 | 6 | 2 | 9 | 8 | 4.7 |

| 650000 | 1 | 1 | 7 | 1 | 5 | 6 | 6 | 1 | 7 | 8 | 4.3 |

| 660000 | 9 | 6 | 11 | 6 | 0 | 7 | 6 | 7 | 2 | 3 | 5.7 |

| 670000 | 5 | 5 | 8 | 8 | 6 | 4 | 9 | 4 | 6 | 7 | 6.2 |

| 680000 | 2 | 5 | 9 | 12 | 5 | 4 | 7 | 8 | 8 | 10 | 7.0 |

| 690000 | 9 | 15 | 11 | 8 | 1 | 7 | 12 | 7 | 5 | 3 | 7.8 |

| 700000 | 6 | 3 | 3 | 9 | 8 | 7 | 3 | 5 | 10 | 10 | 6.4 |

| 710000 | 3 | 3 | 6 | 9 | 4 | 6 | 6 | 9 | 8 | 1 | 5.5 |

| 720000 | 6 | 2 | 6 | 8 | 7 | 7 | 2 | 0 | 6 | 2 | 4.6 |

| 730000 | 13 | 7 | 7 | 4 | 4 | 8 | 6 | 0 | 9 | 5 | 6.3 |

| 740000 | 7 | 3 | 13 | 12 | 11 | 7 | 16 | 9 | 5 | 1 | 8.4 |

| 750000 | 9 | 13 | 7 | 9 | 6 | 9 | 8 | 11 | 4 | 9 | 8.5 |

| 760000 | 6 | 11 | 1 | 9 | 1 | 9 | 3 | 5 | 9 | 7 | 6.1 |

| 770000 | 3 | 8 | 9 | 13 | 8 | 10 | 11 | 10 | 12 | 4 | 8.8 |

| 780000 | 6 | 6 | 10 | 8 | 3 | 2 | 7 | 9 | 7 | 9 | 6.7 |

| 790000 | 1 | 11 | 5 | 6 | 6 | 4 | 8 | 7 | 3 | 7 | 5.8 |

| 800000 | 4 | 2 | 1 | 0 | 5 | 14 | 5 | 10 | 14 | 7 | 6.2 |

| 810000 | 9 | 7 | 4 | 4 | 3 | 10 | 13 | 1 | 9 | 10 | 7.0 |

| 820000 | 2 | 8 | 9 | 6 | 2 | 9 | 11 | 0 | 3 | 8 | 5.8 |

| 830000 | 9 | 4 | 7 | 1 | 11 | 7 | 13 | 14 | 2 | 3 | 7.1 |

| 840000 | 16 | 7 | 7 | 5 | 12 | 14 | 1 | 2 | 11 | 11 | 8.6 |

| 850000 | 9 | 6 | 12 | 10 | 14 | 8 | 12 | 12 | 3 | 11 | 9.7 |

| 860000 | 5 | 1 | 1 | 4 | 8 | 11 | 2 | 5 | 2 | 8 | 4.7 |

| 870000 | 2 | 14 | 9 | 4 | 15 | 1 | 17 | 6 | 11 | 3 | 8.2 |

| 880000 | 7 | 1 | 6 | 12 | 7 | 2 | 11 | 6 | 12 | 10 | 7.4 |

| 890000 | 11 | 12 | 13 | 6 | 4 | 8 | 2 | 7 | 9 | 4 | 7.6 |

| 900000 | 3 | 6 | 11 | 9 | 6 | 11 | 15 | 2 | 12 | 9 | 8.4 |

| 910000 | 12 | 12 | 4 | 2 | 4 | 12 | 13 | 4 | 3 | 6 | 7.2 |

| 920000 | 9 | 0 | 9 | 1 | 5 | 11 | 0 | 2 | 10 | 5 | 5.2 |

| 930000 | 10 | 4 | 4 | 13 | 2 | 4 | 12 | 3 | 11 | 5 | 6.8 |

| 940000 | 18 | 6 | 12 | 4 | 12 | 2 | 17 | 8 | 10 | 3 | 9.2 |

| 950000 | 15 | 2 | 11 | 14 | 12 | 10 | 15 | 16 | 18 | 6 | 11.9 |

| 960000 | 9 | 3 | 18 | 5 | 8 | 13 | 8 | 5 | 12 | 14 | 9.5 |

| 970000 | 7 | 4 | 11 | 2 | 12 | 1 | 3 | 10 | 11 | 12 | 7.3 |

| 980000 | 8 | 13 | 6 | 15 | 12 | 6 | 8 | 6 | 7 | 14 | 9.5 |

| 990000 | 12 | 9 | 8 | 8 | 9 | 9 | 6 | 11 | 7 | 14 | 9.3 |

| 1000000 | 9 | 5 | 6 | 7 | 7 | 1 | 3 | 16 | 8 | 15 | 7.7 |

**Sorted input by choosing pivot as middle element**

| InputSize| Time1| Time2| Time3| Time4| Time5| Time6| Time7| Time8| Time9| Time10| Avg Time|

|===========================================================================================|

| 10000 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.0 |

| 20000 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.0 |

| 30000 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.0 |

| 40000 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.0 |

| 50000 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.0 |

| 60000 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.0 |

| 70000 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.0 |

| 80000 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.0 |

| 90000 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.0 |

| 100000 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.0 |

| 110000 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.0 |

| 120000 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.0 |

| 130000 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.0 |

| 140000 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.0 |

| 150000 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.0 |

| 160000 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.0 |

| 170000 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.0 |

| 180000 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.0 |

| 190000 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.0 |

| 200000 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.0 |

| 210000 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.0 |

| 220000 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.0 |

| 230000 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.0 |

| 240000 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.0 |

| 250000 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.0 |

| 260000 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.0 |

| 270000 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.0 |

| 280000 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.0 |

| 290000 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.0 |

| 300000 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.0 |

| 310000 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.0 |

| 320000 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.0 |

| 330000 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.0 |

| 340000 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.0 |

| 350000 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.0 |

| 360000 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.0 |

| 370000 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.0 |

| 380000 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.0 |

| 390000 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.0 |

| 400000 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.0 |

| 410000 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.0 |

| 420000 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.1 |

| 430000 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.0 |

| 440000 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.0 |

| 450000 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.0 |

| 460000 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.0 |

| 470000 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.0 |

| 480000 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.0 |

| 490000 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.0 |

| 500000 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.0 |

| 510000 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.0 |

| 520000 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 0.2 |

| 530000 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.0 |

| 540000 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.0 |

| 550000 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.0 |

| 560000 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.0 |

| 570000 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.0 |

| 580000 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.0 |

| 590000 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.0 |

| 600000 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0.1 |

| 610000 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.0 |

| 620000 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0.1 |

| 630000 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.0 |

| 640000 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.0 |

| 650000 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.0 |

| 660000 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.0 |

| 670000 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.0 |

| 680000 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.0 |

| 690000 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.0 |

| 700000 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.1 |

| 710000 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.0 |

| 720000 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.1 |

| 730000 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.0 |

| 740000 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.1 |

| 750000 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.0 |

| 760000 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.1 |

| 770000 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.0 |

| 780000 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.0 |

| 790000 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.0 |

| 800000 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.0 |

| 810000 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.0 |

| 820000 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.0 |

| 830000 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.0 |

| 840000 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.0 |

| 850000 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.0 |

| 860000 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0.1 |

| 870000 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.0 |

| 880000 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.0 |

| 890000 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0.1 |

| 900000 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0.1 |

| 910000 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.1 |

| 920000 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0.1 |

| 930000 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.0 |

| 940000 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 0 | 0.3 |

| 950000 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.0 |

| 960000 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0.3 |

| 970000 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 0.3 |

| 980000 | 1 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 0.3 |

| 990000 | 0 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0.2 |

| 1000000 | 0 | 0 | 0 | 1 | 0 | 1 | 1 | 0 | 0 | 0 | 0.3 |

**Partially Sorted Input**

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

| InputSize| Time1| Time2| Time3| Time4| Time5| Time6| Time7| Time8| Time9| Time10| Avg Time|

|===========================================================================================|

| 10000 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.0 |

| 20000 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.2 |

| 30000 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.0 |

| 40000 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.0 |

| 50000 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.0 |

| 60000 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 0.2 |

| 70000 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.0 |

| 80000 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0.1 |

| 90000 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.1 |

| 100000 | 0 | 0 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0.2 |

| 110000 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0.2 |

| 120000 | 1 | 1 | 1 | 2 | 0 | 0 | 1 | 1 | 1 | 0 | 0.8 |

| 130000 | 0 | 1 | 1 | 0 | 1 | 1 | 0 | 0 | 0 | 0 | 0.4 |

| 140000 | 0 | 1 | 1 | 0 | 0 | 2 | 1 | 2 | 1 | 1 | 0.9 |

| 150000 | 0 | 2 | 0 | 1 | 1 | 0 | 1 | 2 | 0 | 1 | 0.8 |

| 160000 | 1 | 2 | 2 | 1 | 0 | 2 | 2 | 1 | 2 | 1 | 1.4 |

| 170000 | 4 | 1 | 0 | 3 | 1 | 2 | 1 | 2 | 1 | 3 | 1.8 |

| 180000 | 1 | 0 | 2 | 1 | 0 | 2 | 1 | 2 | 2 | 0 | 1.1 |

| 190000 | 2 | 2 | 1 | 0 | 0 | 0 | 1 | 0 | 3 | 1 | 1.0 |

| 200000 | 1 | 0 | 2 | 2 | 1 | 2 | 1 | 2 | 2 | 2 | 1.5 |

| 210000 | 1 | 0 | 0 | 1 | 2 | 1 | 3 | 2 | 2 | 3 | 1.5 |

| 220000 | 1 | 0 | 1 | 2 | 2 | 3 | 2 | 4 | 1 | 0 | 1.6 |

| 230000 | 1 | 3 | 1 | 1 | 4 | 2 | 2 | 2 | 0 | 2 | 1.8 |

| 240000 | 2 | 0 | 2 | 2 | 1 | 3 | 1 | 3 | 2 | 1 | 1.7 |

| 250000 | 1 | 2 | 3 | 2 | 2 | 3 | 3 | 2 | 1 | 1 | 2.0 |

| 260000 | 1 | 0 | 2 | 0 | 4 | 4 | 2 | 3 | 2 | 2 | 2.0 |

| 270000 | 4 | 2 | 2 | 2 | 0 | 3 | 1 | 2 | 0 | 0 | 1.6 |

| 280000 | 2 | 2 | 4 | 13 | 5 | 1 | 1 | 3 | 4 | 2 | 3.7 |

| 290000 | 2 | 5 | 3 | 4 | 2 | 0 | 2 | 1 | 4 | 1 | 2.4 |

| 300000 | 3 | 3 | 5 | 1 | 2 | 4 | 0 | 2 | 0 | 2 | 2.2 |

| 310000 | 2 | 2 | 5 | 3 | 0 | 3 | 0 | 2 | 0 | 4 | 2.1 |

| 320000 | 2 | 4 | 3 | 3 | 2 | 2 | 1 | 2 | 1 | 3 | 2.3 |

| 330000 | 3 | 4 | 5 | 3 | 0 | 2 | 0 | 2 | 2 | 2 | 2.3 |

| 340000 | 2 | 4 | 5 | 0 | 2 | 4 | 3 | 4 | 5 | 2 | 3.1 |

| 350000 | 2 | 5 | 2 | 2 | 3 | 2 | 3 | 3 | 5 | 0 | 2.7 |

| 360000 | 4 | 3 | 3 | 1 | 3 | 5 | 5 | 4 | 0 | 6 | 3.4 |

| 370000 | 2 | 3 | 2 | 6 | 3 | 2 | 4 | 1 | 0 | 0 | 2.3 |

| 380000 | 4 | 3 | 3 | 6 | 2 | 0 | 1 | 2 | 3 | 1 | 2.5 |

| 390000 | 2 | 7 | 4 | 3 | 3 | 0 | 3 | 6 | 6 | 4 | 3.8 |

| 400000 | 3 | 4 | 3 | 5 | 2 | 3 | 1 | 2 | 6 | 4 | 3.3 |

| 410000 | 2 | 4 | 3 | 0 | 6 | 4 | 1 | 4 | 6 | 5 | 3.5 |

| 420000 | 5 | 1 | 2 | 2 | 8 | 2 | 6 | 6 | 3 | 1 | 3.6 |

| 430000 | 5 | 3 | 5 | 0 | 0 | 3 | 3 | 1 | 3 | 3 | 2.6 |

| 440000 | 5 | 5 | 2 | 5 | 5 | 7 | 4 | 4 | 6 | 5 | 4.8 |

| 450000 | 1 | 6 | 7 | 6 | 3 | 1 | 1 | 3 | 3 | 7 | 3.8 |

| 460000 | 5 | 3 | 1 | 5 | 3 | 4 | 1 | 7 | 5 | 4 | 3.8 |

| 470000 | 8 | 5 | 2 | 4 | 3 | 3 | 2 | 3 | 1 | 3 | 3.4 |

| 480000 | 6 | 6 | 5 | 6 | 7 | 0 | 5 | 7 | 2 | 5 | 4.9 |

| 490000 | 5 | 9 | 8 | 5 | 6 | 4 | 5 | 1 | 1 | 2 | 4.6 |

| 500000 | 2 | 3 | 3 | 4 | 6 | 3 | 1 | 1 | 3 | 2 | 2.8 |

| 510000 | 1 | 6 | 1 | 2 | 5 | 3 | 5 | 8 | 3 | 2 | 3.6 |

| 520000 | 5 | 0 | 6 | 9 | 4 | 1 | 5 | 1 | 8 | 4 | 4.3 |

| 530000 | 4 | 6 | 6 | 6 | 6 | 6 | 6 | 6 | 0 | 1 | 4.7 |

| 540000 | 7 | 6 | 0 | 3 | 6 | 7 | 6 | 4 | 4 | 3 | 4.6 |

| 550000 | 4 | 4 | 6 | 8 | 7 | 9 | 8 | 5 | 7 | 3 | 6.1 |

| 560000 | 5 | 5 | 5 | 8 | 4 | 0 | 1 | 5 | 7 | 1 | 4.1 |

| 570000 | 7 | 0 | 2 | 3 | 9 | 3 | 8 | 0 | 5 | 4 | 4.1 |

| 580000 | 1 | 2 | 5 | 5 | 7 | 6 | 3 | 7 | 4 | 5 | 4.5 |

| 590000 | 3 | 8 | 6 | 6 | 4 | 5 | 5 | 10 | 2 | 2 | 5.1 |

| 600000 | 7 | 7 | 8 | 6 | 9 | 4 | 5 | 6 | 7 | 2 | 6.1 |

| 610000 | 5 | 4 | 3 | 10 | 5 | 4 | 5 | 1 | 3 | 6 | 4.6 |

| 620000 | 4 | 7 | 13 | 2 | 0 | 9 | 1 | 9 | 4 | 4 | 5.3 |

| 630000 | 6 | 5 | 3 | 7 | 1 | 5 | 5 | 2 | 2 | 3 | 3.9 |

| 640000 | 4 | 0 | 1 | 6 | 0 | 4 | 8 | 3 | 5 | 6 | 3.7 |

| 650000 | 7 | 6 | 2 | 5 | 4 | 6 | 4 | 8 | 12 | 5 | 5.9 |

| 660000 | 10 | 5 | 5 | 11 | 8 | 6 | 10 | 9 | 7 | 4 | 7.5 |

| 670000 | 5 | 4 | 4 | 5 | 6 | 2 | 10 | 6 | 11 | 4 | 5.7 |

| 680000 | 3 | 8 | 8 | 5 | 7 | 4 | 3 | 5 | 1 | 1 | 4.5 |

| 690000 | 1 | 2 | 11 | 8 | 4 | 6 | 7 | 6 | 9 | 6 | 6.0 |

| 700000 | 3 | 4 | 2 | 1 | 8 | 5 | 7 | 8 | 9 | 3 | 5.0 |

| 710000 | 7 | 2 | 4 | 10 | 4 | 1 | 4 | 6 | 3 | 4 | 4.5 |

| 720000 | 4 | 5 | 10 | 10 | 11 | 3 | 5 | 6 | 6 | 5 | 6.5 |

| 730000 | 5 | 8 | 6 | 7 | 9 | 3 | 5 | 7 | 4 | 8 | 6.2 |

| 740000 | 4 | 10 | 6 | 9 | 2 | 8 | 3 | 3 | 5 | 2 | 5.2 |

| 750000 | 7 | 4 | 1 | 5 | 10 | 7 | 10 | 5 | 13 | 6 | 6.8 |

| 760000 | 6 | 9 | 8 | 13 | 9 | 10 | 10 | 6 | 8 | 5 | 8.4 |

| 770000 | 9 | 9 | 4 | 9 | 4 | 11 | 11 | 12 | 9 | 12 | 9.0 |

| 780000 | 9 | 6 | 10 | 5 | 11 | 1 | 3 | 4 | 4 | 5 | 5.8 |

| 790000 | 2 | 6 | 9 | 9 | 9 | 12 | 6 | 1 | 3 | 9 | 6.6 |

| 800000 | 9 | 5 | 5 | 8 | 9 | 0 | 2 | 9 | 12 | 9 | 6.8 |

| 810000 | 10 | 4 | 5 | 7 | 5 | 8 | 6 | 18 | 1 | 9 | 7.3 |

| 820000 | 9 | 7 | 10 | 2 | 10 | 11 | 3 | 11 | 8 | 8 | 7.9 |

| 830000 | 8 | 6 | 13 | 7 | 4 | 8 | 8 | 5 | 5 | 4 | 6.8 |

| 840000 | 10 | 7 | 14 | 14 | 11 | 11 | 6 | 5 | 11 | 6 | 9.5 |

| 850000 | 5 | 7 | 2 | 7 | 6 | 7 | 9 | 8 | 4 | 15 | 7.0 |

| 860000 | 8 | 9 | 8 | 7 | 5 | 5 | 10 | 2 | 12 | 2 | 6.8 |

| 870000 | 7 | 6 | 9 | 5 | 2 | 8 | 3 | 7 | 7 | 11 | 6.5 |

| 880000 | 5 | 10 | 11 | 11 | 8 | 4 | 10 | 13 | 6 | 9 | 8.7 |

| 890000 | 9 | 11 | 9 | 4 | 12 | 3 | 9 | 4 | 6 | 7 | 7.4 |

| 900000 | 4 | 12 | 2 | 2 | 11 | 2 | 14 | 4 | 9 | 9 | 6.9 |

| 910000 | 9 | 7 | 1 | 8 | 4 | 14 | 1 | 2 | 8 | 0 | 5.4 |

| 920000 | 4 | 6 | 5 | 5 | 12 | 3 | 15 | 12 | 8 | 7 | 7.7 |

| 930000 | 11 | 8 | 13 | 3 | 2 | 3 | 4 | 9 | 12 | 10 | 7.5 |

| 940000 | 6 | 1 | 13 | 11 | 14 | 13 | 9 | 10 | 1 | 9 | 8.7 |

| 950000 | 7 | 7 | 11 | 3 | 1 | 7 | 9 | 11 | 11 | 10 | 7.7 |

| 960000 | 10 | 12 | 4 | 12 | 11 | 7 | 9 | 6 | 12 | 14 | 9.7 |

| 970000 | 8 | 3 | 14 | 11 | 15 | 12 | 3 | 9 | 10 | 13 | 9.8 |

| 980000 | 2 | 3 | 2 | 2 | 13 | 1 | 1 | 10 | 5 | 12 | 5.1 |

| 990000 | 16 | 1 | 11 | 9 | 13 | 14 | 9 | 10 | 13 | 4 | 10.0 |

| 1000000 | 1 | 10 | 1 | 4 | 15 | 10 | 9 | 9 | 9 | 10 | 7.8 |

**Mathematical Analysis**

Total no of compares can range from order of N^2 to NlgN depending on the pivot selected

Therefore total running time = O(NlgN)

Average case running time =Best case running time O(NlgN)

Average case running time can be attained by shuffling the input elements.

Quick Sort space complexity is O(1).

Theoretically complexity of quick sort is 1.39NllgN

**Determining Constant .**

**N, T(N) NlgN T(N)/NlgN**

|  |  |  |  |
| --- | --- | --- | --- |
| 10000 | 0.1 | 132877.1 | 0.075257 |
| 20000 | 0.2 | 265754.2 | 0.075257 |
| 30000 | 0 | 398631.4 | 0.075257 |
| 40000 | 0 | 531508.5 | 0.075257 |
| 50000 | 0 | 664385.6 | 0.075257 |
| 60000 | 0 | 797262.7 | 0.075257 |
| 70000 | 0.4 | 930139.9 | 0.075257 |
| 80000 | 0.2 | 1063017 | 0.075257 |
| 90000 | 0.3 | 1195894 | 0.075257 |
| 100000 | 0.3 | 1328771 | 0.075257 |
| 110000 | 0.6 | 1461648 | 0.075257 |
| 120000 | 0.7 | 1594525 | 0.075257 |
| 130000 | 0.6 | 1727403 | 0.075257 |
| 140000 | 0.9 | 1860280 | 0.075257 |
| 150000 | 1 | 1993157 | 0.075257 |
| 160000 | 1 | 2126034 | 0.075257 |
| 170000 | 0.8 | 2258911 | 0.075257 |
| 180000 | 0.8 | 2391788 | 0.075257 |
| 190000 | 1.5 | 2524665 | 0.075257 |
| 200000 | 1.4 | 2657542 | 0.075257 |
| 210000 | 1.8 | 2790420 | 0.075257 |
| 220000 | 2.1 | 2923297 | 0.075257 |
| 230000 | 1.7 | 3056174 | 0.075257 |
| 240000 | 3 | 3189051 | 0.075257 |
| 250000 | 3 | 3321928 | 0.075257 |
| 260000 | 2.3 | 3454805 | 0.075257 |
| 270000 | 2.3 | 3587682 | 0.075257 |
| 280000 | 2.2 | 3720559 | 0.075257 |
| 290000 | 2.1 | 3853437 | 0.075257 |
| 300000 | 2.8 | 3986314 | 0.075257 |
| 310000 | 2.8 | 4119191 | 0.075257 |
| 320000 | 2.7 | 4252068 | 0.075257 |
| 330000 | 2.8 | 4384945 | 0.075257 |
| 340000 | 3.5 | 4517822 | 0.075257 |
| 350000 | 3.4 | 4650699 | 0.075257 |
| 360000 | 3.8 | 4783576 | 0.075257 |
| 370000 | 2.7 | 4916454 | 0.075257 |
| 380000 | 3.3 | 5049331 | 0.075257 |
| 390000 | 3.4 | 5182208 | 0.075257 |
| 400000 | 3.6 | 5315085 | 0.075257 |
| 410000 | 2.4 | 5447962 | 0.075257 |
| 420000 | 4.4 | 5580839 | 0.075257 |
| 430000 | 4.3 | 5713716 | 0.075257 |
| 440000 | 3.9 | 5846593 | 0.075257 |
| 450000 | 4.3 | 5979471 | 0.075257 |
| 460000 | 5.5 | 6112348 | 0.075257 |
| 470000 | 3.7 | 6245225 | 0.075257 |
| 480000 | 6.1 | 6378102 | 0.075257 |
| 490000 | 5 | 6510979 | 0.075257 |
| 500000 | 5.1 | 6643856 | 0.075257 |
| 510000 | 5.1 | 6776733 | 0.075257 |
| 520000 | 6.3 | 6909610 | 0.075257 |
| 530000 | 3.3 | 7042488 | 0.075257 |
| 540000 | 4 | 7175365 | 0.075257 |
| 550000 | 6.6 | 7308242 | 0.075257 |
| 560000 | 4.4 | 7441119 | 0.075257 |
| 570000 | 4.7 | 7573996 | 0.075257 |
| 580000 | 4.8 | 7706873 | 0.075257 |
| 590000 | 5.3 | 7839750 | 0.075257 |
| 600000 | 5.6 | 7972627 | 0.075257 |
| 610000 | 4.6 | 8105505 | 0.075257 |
| 620000 | 7.3 | 8238382 | 0.075257 |
| 630000 | 6.3 | 8371259 | 0.075257 |
| 640000 | 6.8 | 8504136 | 0.075257 |
| 650000 | 6.1 | 8637013 | 0.075257 |
| 660000 | 4.7 | 8769890 | 0.075257 |
| 670000 | 5.1 | 8902767 | 0.075257 |
| 680000 | 6.8 | 9035644 | 0.075257 |
| 690000 | 5.8 | 9168522 | 0.075257 |
| 700000 | 7.2 | 9301399 | 0.075257 |
| 710000 | 6 | 9434276 | 0.075257 |
| 720000 | 5.7 | 9567153 | 0.075257 |
| 730000 | 6.7 | 9700030 | 0.075257 |
| 740000 | 7.4 | 9832907 | 0.075257 |
| 750000 | 6.1 | 9965784 | 0.075257 |
| 760000 | 7.9 | 10098661 | 0.075257 |
| 770000 | 9 | 10231539 | 0.075257 |
| 780000 | 6.1 | 10364416 | 0.075257 |
| 790000 | 7.8 | 10497293 | 0.075257 |
| 800000 | 9.4 | 10630170 | 0.075257 |
| 810000 | 9.1 | 10763047 | 0.075257 |
| 820000 | 10.4 | 10895924 | 0.075257 |
| 830000 | 7.1 | 11028801 | 0.075257 |
| 840000 | 8.4 | 11161678 | 0.075257 |
| 850000 | 7.9 | 11294556 | 0.075257 |
| 860000 | 8.9 | 11427433 | 0.075257 |
| 870000 | 7.6 | 11560310 | 0.075257 |
| 880000 | 9.3 | 11693187 | 0.075257 |
| 890000 | 9.9 | 11826064 | 0.075257 |
| 900000 | 10.6 | 11958941 | 0.075257 |
| 910000 | 10.2 | 12091818 | 0.075257 |
| 920000 | 7.7 | 12224695 | 0.075257 |
| 930000 | 7.9 | 12357573 | 0.075257 |
| 940000 | 11.8 | 12490450 | 0.075257 |
| 950000 | 10.1 | 12623327 | 0.075257 |
| 960000 | 11.1 | 12756204 | 0.075257 |
| 970000 | 8.2 | 12889081 | 0.075257 |
| 980000 | 8.7 | 13021958 | 0.075257 |
| 990000 | 10.7 | 13154835 | 0.075257 |
| 1000000 | 9 | 13287712 | 0.075257 |
|  |  |  | 0.075257 |

**K = T(N)/NlgN =** 0.075257

**HeapSort**

\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_

| InputSize| Time1| Time2| Time3| Time4| Time5| Time6| Time7| Time8| Time9| Time10| Avg Time|

|===========================================================================================|

| 10000 | 3 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1.2 |

| 20000 | 3 | 9 | 3 | 2 | 2 | 2 | 2 | 2 | 2 | 2 | 2.9 |

| 30000 | 5 | 5 | 5 | 5 | 3 | 3 | 5 | 5 | 3 | 4 | 4.3 |

| 40000 | 5 | 5 | 6 | 5 | 5 | 7 | 7 | 5 | 5 | 6 | 5.6 |

| 50000 | 6 | 8 | 7 | 7 | 9 | 7 | 6 | 7 | 6 | 7 | 7.0 |

| 60000 | 11 | 9 | 9 | 9 | 8 | 9 | 10 | 12 | 11 | 8 | 9.6 |

| 70000 | 10 | 10 | 9 | 9 | 9 | 9 | 10 | 9 | 10 | 10 | 9.5 |

| 80000 | 12 | 11 | 11 | 14 | 12 | 13 | 13 | 11 | 15 | 11 | 12.3 |

| 90000 | 13 | 13 | 15 | 16 | 16 | 13 | 14 | 15 | 14 | 17 | 14.6 |

| 100000 | 16 | 16 | 21 | 16 | 18 | 17 | 19 | 19 | 15 | 14 | 17.1 |

| 110000 | 17 | 19 | 17 | 16 | 17 | 17 | 19 | 17 | 22 | 18 | 17.9 |

| 120000 | 22 | 21 | 20 | 24 | 20 | 19 | 18 | 19 | 20 | 18 | 20.1 |

| 130000 | 25 | 20 | 25 | 24 | 26 | 19 | 26 | 21 | 23 | 19 | 22.8 |

| 140000 | 21 | 24 | 21 | 27 | 22 | 23 | 26 | 24 | 22 | 22 | 23.2 |

| 150000 | 24 | 24 | 26 | 26 | 23 | 28 | 26 | 24 | 24 | 22 | 24.7 |

| 160000 | 29 | 28 | 30 | 25 | 28 | 28 | 31 | 29 | 26 | 29 | 28.3 |

| 170000 | 31 | 29 | 29 | 29 | 34 | 29 | 29 | 27 | 29 | 30 | 29.6 |

| 180000 | 34 | 27 | 34 | 34 | 35 | 34 | 28 | 32 | 28 | 32 | 31.8 |

| 190000 | 37 | 31 | 37 | 32 | 35 | 37 | 35 | 38 | 35 | 32 | 34.9 |

| 200000 | 38 | 38 | 39 | 35 | 32 | 35 | 33 | 31 | 36 | 41 | 35.8 |

| 210000 | 35 | 40 | 40 | 36 | 34 | 40 | 34 | 37 | 43 | 38 | 37.7 |

| 220000 | 43 | 41 | 42 | 40 | 47 | 44 | 43 | 44 | 38 | 38 | 42.0 |

| 230000 | 39 | 40 | 44 | 46 | 49 | 50 | 49 | 45 | 48 | 51 | 46.1 |

| 240000 | 47 | 50 | 50 | 52 | 47 | 50 | 49 | 51 | 47 | 43 | 48.6 |

| 250000 | 48 | 47 | 47 | 46 | 52 | 49 | 46 | 40 | 46 | 45 | 46.6 |

| 260000 | 55 | 56 | 45 | 50 | 47 | 48 | 45 | 49 | 53 | 50 | 49.8 |

| 270000 | 45 | 51 | 45 | 58 | 48 | 52 | 49 | 56 | 49 | 50 | 50.3 |

| 280000 | 54 | 50 | 49 | 55 | 51 | 52 | 52 | 54 | 56 | 54 | 52.7 |

| 290000 | 53 | 59 | 53 | 57 | 59 | 54 | 58 | 56 | 63 | 51 | 56.3 |

| 300000 | 53 | 52 | 54 | 66 | 54 | 59 | 58 | 58 | 52 | 62 | 56.8 |

| 310000 | 58 | 57 | 55 | 60 | 56 | 58 | 55 | 58 | 54 | 60 | 57.1 |

| 320000 | 55 | 60 | 58 | 61 | 62 | 63 | 63 | 66 | 59 | 58 | 60.5 |

| 330000 | 60 | 69 | 71 | 62 | 70 | 63 | 59 | 67 | 59 | 59 | 63.9 |

| 340000 | 62 | 71 | 66 | 67 | 70 | 68 | 62 | 72 | 65 | 72 | 67.5 |

| 350000 | 71 | 73 | 76 | 70 | 74 | 70 | 73 | 68 | 68 | 72 | 71.5 |

| 360000 | 70 | 74 | 74 | 71 | 68 | 73 | 78 | 85 | 85 | 69 | 74.7 |

| 370000 | 78 | 73 | 84 | 76 | 70 | 74 | 71 | 74 | 79 | 80 | 75.9 |

| 380000 | 77 | 77 | 80 | 74 | 82 | 74 | 77 | 83 | 71 | 78 | 77.3 |

| 390000 | 80 | 86 | 93 | 80 | 81 | 77 | 89 | 84 | 82 | 88 | 84.0 |

| 400000 | 82 | 92 | 93 | 88 | 81 | 87 | 81 | 82 | 87 | 80 | 85.3 |

| 410000 | 79 | 80 | 91 | 88 | 86 | 86 | 83 | 87 | 80 | 89 | 84.9 |

| 420000 | 89 | 90 | 94 | 79 | 85 | 87 | 87 | 86 | 87 | 85 | 86.9 |

| 430000 | 90 | 90 | 102 | 98 | 90 | 88 | 90 | 90 | 92 | 90 | 92.0 |

| 440000 | 98 | 99 | 104 | 88 | 92 | 99 | 92 | 91 | 94 | 91 | 94.8 |

| 450000 | 100 | 101 | 106 | 94 | 105 | 94 | 92 | 96 | 85 | 98 | 97.1 |

| 460000 | 105 | 105 | 105 | 100 | 105 | 103 | 93 | 101 | 94 | 102 | 101.3 |

| 470000 | 99 | 103 | 111 | 112 | 109 | 108 | 96 | 98 | 104 | 100 | 104.0 |

| 480000 | 106 | 115 | 107 | 110 | 104 | 101 | 110 | 110 | 108 | 105 | 107.6 |

| 490000 | 105 | 121 | 134 | 135 | 132 | 133 | 124 | 121 | 126 | 120 | 125.1 |

| 500000 | 112 | 140 | 120 | 110 | 112 | 114 | 109 | 109 | 111 | 115 | 115.2 |

| 510000 | 114 | 121 | 171 | 120 | 113 | 112 | 120 | 116 | 110 | 117 | 121.4 |

| 520000 | 121 | 129 | 122 | 123 | 116 | 117 | 124 | 124 | 118 | 121 | 121.5 |

| 530000 | 123 | 126 | 121 | 128 | 127 | 109 | 115 | 125 | 117 | 165 | 125.6 |

| 540000 | 131 | 122 | 130 | 117 | 125 | 179 | 139 | 123 | 129 | 132 | 132.7 |

| 550000 | 145 | 179 | 133 | 122 | 143 | 164 | 123 | 133 | 117 | 181 | 144.0 |

| 560000 | 134 | 143 | 140 | 154 | 158 | 144 | 136 | 140 | 146 | 167 | 146.2 |

| 570000 | 135 | 144 | 144 | 187 | 137 | 125 | 179 | 135 | 133 | 126 | 144.5 |

| 580000 | 127 | 189 | 138 | 135 | 131 | 128 | 132 | 177 | 131 | 135 | 142.3 |

| 590000 | 140 | 148 | 134 | 144 | 142 | 144 | 150 | 142 | 151 | 135 | 143.0 |

| 600000 | 150 | 167 | 181 | 144 | 141 | 141 | 160 | 175 | 166 | 159 | 158.4 |

| 610000 | 146 | 155 | 320 | 228 | 310 | 331 | 317 | 229 | 201 | 195 | 243.2 |

| 620000 | 153 | 148 | 164 | 173 | 148 | 156 | 211 | 202 | 210 | 249 | 181.4 |

| 630000 | 312 | 336 | 241 | 241 | 224 | 156 | 156 | 156 | 154 | 158 | 213.4 |

| 640000 | 153 | 172 | 150 | 167 | 168 | 145 | 164 | 178 | 151 | 137 | 158.5 |

| 650000 | 147 | 160 | 158 | 142 | 151 | 181 | 195 | 159 | 175 | 270 | 173.8 |

| 660000 | 226 | 209 | 173 | 187 | 165 | 167 | 185 | 184 | 178 | 183 | 185.7 |

| 670000 | 212 | 184 | 151 | 157 | 150 | 153 | 159 | 165 | 148 | 164 | 164.3 |

| 680000 | 170 | 149 | 163 | 158 | 163 | 176 | 153 | 157 | 152 | 147 | 158.8 |

| 690000 | 167 | 176 | 167 | 173 | 182 | 166 | 164 | 175 | 151 | 153 | 167.4 |

| 700000 | 158 | 156 | 158 | 161 | 163 | 166 | 180 | 160 | 169 | 175 | 164.6 |

| 710000 | 166 | 206 | 193 | 174 | 189 | 182 | 181 | 176 | 191 | 179 | 183.7 |

| 720000 | 279 | 185 | 165 | 185 | 160 | 171 | 173 | 176 | 184 | 164 | 184.2 |

| 730000 | 174 | 184 | 180 | 172 | 185 | 175 | 180 | 181 | 185 | 187 | 180.3 |

| 740000 | 172 | 201 | 168 | 185 | 174 | 181 | 161 | 164 | 173 | 170 | 174.9 |

| 750000 | 172 | 190 | 167 | 166 | 173 | 175 | 177 | 159 | 181 | 178 | 173.8 |

| 760000 | 178 | 186 | 171 | 165 | 173 | 174 | 180 | 169 | 167 | 184 | 174.7 |

| 770000 | 183 | 187 | 182 | 178 | 182 | 173 | 176 | 174 | 176 | 169 | 178.0 |

| 780000 | 186 | 180 | 186 | 171 | 183 | 183 | 183 | 180 | 179 | 183 | 181.4 |

| 790000 | 184 | 193 | 185 | 182 | 177 | 176 | 186 | 185 | 175 | 176 | 181.9 |

| 800000 | 193 | 176 | 186 | 188 | 189 | 176 | 179 | 191 | 181 | 183 | 184.2 |

| 810000 | 178 | 186 | 195 | 188 | 183 | 190 | 190 | 187 | 189 | 176 | 186.2 |

| 820000 | 196 | 185 | 189 | 183 | 196 | 183 | 186 | 185 | 188 | 191 | 188.2 |

| 830000 | 189 | 203 | 186 | 194 | 182 | 188 | 178 | 188 | 190 | 190 | 188.8 |

| 840000 | 195 | 202 | 191 | 195 | 192 | 189 | 190 | 200 | 194 | 190 | 193.8 |

| 850000 | 213 | 199 | 198 | 189 | 195 | 196 | 188 | 200 | 177 | 191 | 194.6 |

| 860000 | 208 | 205 | 206 | 199 | 189 | 194 | 201 | 199 | 200 | 199 | 200.0 |

| 870000 | 206 | 205 | 194 | 191 | 196 | 201 | 197 | 202 | 187 | 203 | 198.2 |

| 880000 | 186 | 208 | 196 | 194 | 192 | 201 | 204 | 204 | 206 | 216 | 200.7 |

| 890000 | 233 | 229 | 222 | 217 | 219 | 214 | 215 | 225 | 234 | 223 | 223.1 |

| 900000 | 229 | 221 | 217 | 231 | 237 | 229 | 243 | 226 | 219 | 225 | 227.7 |

| 910000 | 228 | 222 | 227 | 233 | 223 | 227 | 219 | 230 | 222 | 235 | 226.6 |

| 920000 | 238 | 274 | 263 | 285 | 244 | 229 | 224 | 224 | 231 | 236 | 244.8 |

| 930000 | 238 | 249 | 234 | 235 | 225 | 251 | 241 | 246 | 229 | 240 | 238.8 |

| 940000 | 234 | 248 | 245 | 252 | 239 | 246 | 250 | 260 | 238 | 247 | 245.9 |

| 950000 | 261 | 249 | 253 | 257 | 264 | 238 | 245 | 248 | 240 | 247 | 250.2 |

| 960000 | 253 | 241 | 238 | 247 | 247 | 249 | 238 | 231 | 246 | 260 | 245.0 |

| 970000 | 258 | 263 | 245 | 247 | 249 | 247 | 246 | 254 | 243 | 235 | 248.7 |

| 980000 | 249 | 257 | 253 | 257 | 228 | 255 | 254 | 248 | 241 | 248 | 249.0 |

| 990000 | 264 | 253 | 257 | 244 | 258 | 259 | 255 | 247 | 266 | 240 | 254.3 |

| 1000000 | 267 | 237 | 248 | 247 | 243 | 260 | 244 | 271 | 255 | 254 | 252.6 |

**Mathematical Analysis**

**H**eap construction uses ≤ 2 N compares and exchanges.

Heapsort uses ≤ 2 N lg N compares and exchanges.

In-place sorting algorithm with N log N worst-case.

Average case running time =Best case running time = Average case running time O(NlgN)

space complexity is O(1).

Theoretically complexity of is 2NllgN

**Determining Constants**

**N T(N) NlgN T(N)/NlgN**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| 10000 |  | 1.7 | 132877.1 | 1.27938E-05 |
| 20000 |  | 3.2 | 285754.2 | 1.11984E-05 |
| 30000 |  | 4.3 | 446180.2 | 9.63736E-06 |
| 40000 |  | 5.7 | 611508.5 | 9.32121E-06 |
| 50000 |  | 8.3 | 780482 | 1.06345E-05 |
| 60000 |  | 10.2 | 952360.5 | 1.07102E-05 |
| 70000 |  | 11.3 | 1126655 | 1.00297E-05 |
| 80000 |  | 12.6 | 1303017 | 9.66987E-06 |
| 90000 |  | 17.5 | 1481187 | 1.18148E-05 |
| 100000 |  | 18.6 | 1660964 | 1.11983E-05 |
| 110000 |  | 20.3 | 1842186 | 1.10195E-05 |
| 120000 |  | 22.4 | 2024721 | 1.10633E-05 |
| 130000 |  | 23.8 | 2208460 | 1.07767E-05 |
| 140000 |  | 26.6 | 2393309 | 1.11143E-05 |
| 150000 |  | 28.6 | 2579190 | 1.10888E-05 |
| 160000 |  | 32.7 | 2766034 | 1.1822E-05 |
| 170000 |  | 34 | 2953780 | 1.15107E-05 |
| 180000 |  | 35 | 3142375 | 1.11381E-05 |
| 190000 |  | 38.2 | 3331772 | 1.14654E-05 |
| 200000 |  | 38.5 | 3521928 | 1.09315E-05 |
| 210000 |  | 41.7 | 3712806 | 1.12314E-05 |
| 220000 |  | 44 | 3904372 | 1.12694E-05 |
| 230000 |  | 46.6 | 4096593 | 1.13753E-05 |
| 240000 |  | 49.5 | 4289442 | 1.154E-05 |
| 250000 |  | 52.9 | 4482892 | 1.18004E-05 |
| 260000 |  | 52.9 | 4676920 | 1.13109E-05 |
| 270000 |  | 56.8 | 4871502 | 1.16596E-05 |
| 280000 |  | 58.6 | 5066619 | 1.15659E-05 |
| 290000 |  | 62.7 | 5262251 | 1.19151E-05 |
| 300000 |  | 65.4 | 5458381 | 1.19816E-05 |
| 310000 |  | 67.9 | 5654992 | 1.20071E-05 |
| 320000 |  | 68.3 | 5852068 | 1.16711E-05 |
| 330000 |  | 76.4 | 6049595 | 1.26289E-05 |
| 340000 |  | 73.8 | 6247560 | 1.18126E-05 |
| 350000 |  | 78.6 | 6445948 | 1.21937E-05 |
| 360000 |  | 84.7 | 6644749 | 1.27469E-05 |
| 370000 |  | 83.7 | 6843951 | 1.22298E-05 |
| 380000 |  | 84.5 | 7043543 | 1.19968E-05 |
| 390000 |  | 88.8 | 7243515 | 1.22592E-05 |
| 400000 |  | 92.1 | 7443856 | 1.23726E-05 |
| 410000 |  | 92.9 | 7644558 | 1.21524E-05 |
| 420000 |  | 96.6 | 7845613 | 1.23126E-05 |
| 430000 |  | 97.9 | 8047010 | 1.2166E-05 |
| 440000 |  | 102 | 8248743 | 1.23655E-05 |
| 450000 |  | 103.6 | 8450804 | 1.22592E-05 |
| 460000 |  | 109.2 | 8653186 | 1.26196E-05 |
| 470000 |  | 110.5 | 8855882 | 1.24776E-05 |
| 480000 |  | 111.5 | 9058884 | 1.23084E-05 |
| 490000 |  | 119.5 | 9262187 | 1.29019E-05 |
| 500000 |  | 119.6 | 9465784 | 1.2635E-05 |
| 510000 |  | 121.5 | 9669670 | 1.25651E-05 |
| 520000 |  | 129.5 | 9873839 | 1.31155E-05 |
| 530000 |  | 125.7 | 10078285 | 1.24724E-05 |
| 540000 |  | 130.3 | 10283004 | 1.26714E-05 |
| 550000 |  | 142.9 | 10487990 | 1.36251E-05 |
| 560000 |  | 167.3 | 10693238 | 1.56454E-05 |
| 570000 |  | 150.1 | 10898743 | 1.37722E-05 |
| 580000 |  | 170 | 11104502 | 1.53091E-05 |
| 590000 |  | 144 | 11310510 | 1.27315E-05 |
| 600000 |  | 144.5 | 11516762 | 1.25469E-05 |
| 610000 |  | 161.4 | 11723254 | 1.37675E-05 |
| 620000 |  | 150 | 11929983 | 1.25734E-05 |
| 630000 |  | 154.2 | 12136945 | 1.2705E-05 |
| 640000 |  | 160.9 | 12344136 | 1.30345E-05 |
| 650000 |  | 163 | 12551552 | 1.29864E-05 |
| 660000 |  | 163.6 | 12759190 | 1.28221E-05 |
| 670000 |  | 171.4 | 12967047 | 1.32181E-05 |
| 680000 |  | 167.7 | 13175119 | 1.27285E-05 |
| 690000 |  | 169.4 | 13383403 | 1.26575E-05 |
| 700000 |  | 172.7 | 13591897 | 1.27061E-05 |
| 710000 |  | 172.5 | 13800596 | 1.24995E-05 |
| 720000 |  | 181.7 | 14009499 | 1.29698E-05 |
| 730000 |  | 193.4 | 14218602 | 1.36019E-05 |
| 740000 |  | 196.9 | 14427903 | 1.36472E-05 |
| 750000 |  | 185.8 | 14637398 | 1.26935E-05 |
| 760000 |  | 178.9 | 14847086 | 1.20495E-05 |
| 770000 |  | 179 | 15056964 | 1.18882E-05 |
| 780000 |  | 182.2 | 15267029 | 1.19342E-05 |
| 790000 |  | 177.8 | 15477280 | 1.14878E-05 |
| 800000 |  | 184.3 | 15687712 | 1.1748E-05 |
| 810000 |  | 204.7 | 15898326 | 1.28756E-05 |
| 820000 |  | 203.2 | 16109117 | 1.2614E-05 |
| 830000 |  | 216.6 | 16320084 | 1.3272E-05 |
| 840000 |  | 237.9 | 16531225 | 1.43909E-05 |
| 850000 |  | 238.3 | 16742538 | 1.42332E-05 |
| 860000 |  | 228.2 | 16954020 | 1.34599E-05 |
| 870000 |  | 242.7 | 17165671 | 1.41387E-05 |
| 880000 |  | 240.6 | 17377487 | 1.38455E-05 |
| 890000 |  | 245 | 17589467 | 1.39288E-05 |
| 900000 |  | 253 | 17801609 | 1.42122E-05 |
| 910000 |  | 251.6 | 18013911 | 1.3967E-05 |
| 920000 |  | 241.2 | 18226372 | 1.32336E-05 |
| 930000 |  | 244.9 | 18438990 | 1.32816E-05 |
| 940000 |  | 244.2 | 18651763 | 1.30926E-05 |
| 950000 |  | 243.8 | 18864690 | 1.29236E-05 |
| 960000 |  | 246.4 | 19077768 | 1.29156E-05 |
| 970000 |  | 245.2 | 19290996 | 1.27106E-05 |
| 980000 |  | 248.5 | 19504374 | 1.27407E-05 |
| 990000 |  | 272.1 | 19717898 | 1.37996E-05 |
| 1000000 |  | 370.3 | 19931569 | 1.85786E-05 |
|  |  |  |  | 1.24309E-05 |

Constant is calculated using T(N)/NlgN = 1.24309E-05

**Custom Sort**

Combination of Insertion and quick sort

| InputSize| Time1| Time2| Time3| Time4| Time5| Time6| Time7| Time8| Time9| Time10| Avg Time|

|===========================================================================================|

| 10000 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.0 |

| 20000 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.0 |

| 30000 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.1 |

| 40000 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.0 |

| 50000 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.0 |

| 60000 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0.0 |

| 70000 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0.1 |

| 80000 | 0 | 0 | 0 | 0 | 2 | 0 | 0 | 1 | 0 | 0 | 0.3 |

| 90000 | 0 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0.2 |

| 100000 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0.1 |

| 110000 | 1 | 0 | 1 | 0 | 1 | 1 | 0 | 1 | 0 | 0 | 0.5 |

| 120000 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 1 | 1 | 1 | 0.4 |

| 130000 | 1 | 1 | 1 | 0 | 0 | 1 | 1 | 1 | 0 | 1 | 0.7 |

| 140000 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 0.2 |

| 150000 | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 1 | 0 | 1 | 0.6 |

| 160000 | 0 | 1 | 1 | 0 | 1 | 0 | 0 | 0 | 1 | 0 | 0.4 |

| 170000 | 0 | 1 | 0 | 0 | 1 | 0 | 1 | 1 | 0 | 0 | 0.4 |

| 180000 | 1 | 0 | 1 | 1 | 0 | 1 | 1 | 0 | 1 | 1 | 0.7 |

| 190000 | 0 | 2 | 2 | 1 | 2 | 2 | 1 | 3 | 1 | 0 | 1.4 |

| 200000 | 1 | 1 | 1 | 2 | 0 | 1 | 0 | 2 | 1 | 1 | 1.0 |

| 210000 | 1 | 1 | 0 | 1 | 0 | 2 | 3 | 1 | 1 | 1 | 1.1 |

| 220000 | 3 | 2 | 1 | 2 | 3 | 2 | 3 | 2 | 1 | 2 | 2.1 |

| 230000 | 0 | 2 | 2 | 2 | 1 | 2 | 1 | 2 | 1 | 1 | 1.4 |

| 240000 | 0 | 1 | 2 | 2 | 3 | 3 | 1 | 1 | 2 | 3 | 1.8 |

| 250000 | 1 | 0 | 4 | 4 | 4 | 1 | 2 | 1 | 2 | 2 | 2.1 |

| 260000 | 1 | 3 | 2 | 2 | 1 | 3 | 1 | 2 | 3 | 0 | 1.8 |

| 270000 | 2 | 2 | 4 | 0 | 1 | 2 | 3 | 3 | 2 | 1 | 2.0 |

| 280000 | 3 | 3 | 2 | 2 | 2 | 1 | 4 | 2 | 2 | 3 | 2.4 |

| 290000 | 1 | 3 | 3 | 4 | 4 | 1 | 5 | 3 | 2 | 0 | 2.6 |

| 300000 | 3 | 3 | 4 | 1 | 2 | 2 | 2 | 2 | 2 | 3 | 2.4 |

| 310000 | 4 | 3 | 2 | 1 | 1 | 1 | 2 | 0 | 2 | 3 | 1.9 |

| 320000 | 2 | 3 | 5 | 0 | 4 | 2 | 2 | 3 | 3 | 3 | 2.7 |

| 330000 | 2 | 3 | 4 | 2 | 5 | 2 | 0 | 2 | 4 | 3 | 2.7 |

| 340000 | 5 | 4 | 1 | 1 | 3 | 3 | 3 | 4 | 1 | 2 | 2.7 |

| 350000 | 4 | 4 | 1 | 3 | 1 | 2 | 2 | 3 | 5 | 4 | 2.9 |

| 360000 | 4 | 2 | 3 | 5 | 1 | 0 | 1 | 5 | 4 | 0 | 2.5 |

| 370000 | 3 | 3 | 1 | 1 | 1 | 2 | 1 | 3 | 4 | 3 | 2.2 |

| 380000 | 3 | 4 | 5 | 1 | 3 | 1 | 6 | 6 | 4 | 4 | 3.7 |

| 390000 | 4 | 1 | 0 | 3 | 0 | 4 | 6 | 5 | 3 | 6 | 3.2 |

| 400000 | 0 | 2 | 3 | 0 | 4 | 2 | 3 | 5 | 3 | 3 | 2.5 |

| 410000 | 2 | 0 | 2 | 5 | 3 | 3 | 1 | 3 | 1 | 0 | 2.0 |

| 420000 | 1 | 5 | 4 | 6 | 4 | 1 | 2 | 1 | 6 | 2 | 3.2 |

| 430000 | 0 | 2 | 5 | 3 | 3 | 5 | 5 | 3 | 0 | 5 | 3.1 |

| 440000 | 5 | 3 | 6 | 1 | 7 | 1 | 0 | 8 | 2 | 3 | 3.6 |

| 450000 | 5 | 3 | 3 | 2 | 3 | 2 | 5 | 4 | 3 | 6 | 3.6 |

| 460000 | 2 | 4 | 3 | 5 | 2 | 5 | 8 | 5 | 3 | 5 | 4.2 |

| 470000 | 6 | 6 | 4 | 4 | 3 | 7 | 2 | 1 | 7 | 5 | 4.5 |

| 480000 | 4 | 6 | 2 | 5 | 2 | 1 | 1 | 4 | 1 | 2 | 2.8 |

| 490000 | 5 | 6 | 3 | 5 | 4 | 0 | 3 | 7 | 4 | 6 | 4.3 |

| 500000 | 5 | 5 | 6 | 6 | 3 | 3 | 5 | 5 | 2 | 6 | 4.6 |

| 510000 | 6 | 1 | 3 | 3 | 1 | 2 | 4 | 8 | 7 | 6 | 4.1 |

| 520000 | 3 | 7 | 2 | 10 | 6 | 8 | 4 | 0 | 3 | 3 | 4.6 |

| 530000 | 5 | 5 | 1 | 7 | 5 | 2 | 6 | 7 | 1 | 1 | 4.0 |

| 540000 | 2 | 8 | 4 | 3 | 8 | 5 | 5 | 5 | 5 | 3 | 4.8 |

| 550000 | 6 | 6 | 6 | 6 | 5 | 8 | 5 | 4 | 7 | 0 | 5.3 |

| 560000 | 4 | 3 | 6 | 6 | 7 | 3 | 3 | 5 | 1 | 8 | 4.6 |

| 570000 | 3 | 3 | 4 | 3 | 4 | 2 | 5 | 7 | 0 | 2 | 3.3 |

| 580000 | 6 | 1 | 5 | 6 | 5 | 6 | 6 | 6 | 5 | 5 | 5.1 |

| 590000 | 2 | 7 | 1 | 6 | 0 | 4 | 9 | 5 | 1 | 3 | 3.8 |

| 600000 | 4 | 9 | 6 | 0 | 7 | 2 | 7 | 5 | 5 | 6 | 5.1 |

| 610000 | 8 | 0 | 6 | 1 | 2 | 4 | 5 | 4 | 2 | 4 | 3.6 |

| 620000 | 7 | 8 | 6 | 6 | 10 | 3 | 4 | 3 | 9 | 6 | 6.2 |

| 630000 | 4 | 5 | 5 | 5 | 7 | 5 | 7 | 6 | 3 | 5 | 5.2 |

| 640000 | 5 | 2 | 1 | 6 | 10 | 0 | 7 | 6 | 8 | 4 | 4.9 |

| 650000 | 5 | 5 | 7 | 4 | 3 | 1 | 9 | 4 | 2 | 3 | 4.3 |

| 660000 | 10 | 1 | 3 | 7 | 7 | 9 | 8 | 4 | 5 | 9 | 6.3 |

| 670000 | 7 | 5 | 5 | 5 | 6 | 6 | 4 | 2 | 2 | 4 | 4.6 |

| 680000 | 7 | 8 | 7 | 7 | 6 | 3 | 1 | 5 | 7 | 6 | 5.7 |

| 690000 | 4 | 1 | 5 | 8 | 7 | 7 | 5 | 7 | 4 | 7 | 5.5 |

| 700000 | 2 | 9 | 2 | 3 | 6 | 1 | 6 | 5 | 9 | 7 | 5.0 |

| 710000 | 5 | 7 | 4 | 10 | 7 | 8 | 1 | 9 | 2 | 4 | 5.7 |

| 720000 | 1 | 6 | 7 | 11 | 6 | 7 | 7 | 3 | 5 | 6 | 5.9 |

| 730000 | 8 | 8 | 7 | 1 | 6 | 9 | 10 | 1 | 4 | 8 | 6.2 |

| 740000 | 3 | 6 | 10 | 9 | 4 | 3 | 6 | 10 | 7 | 6 | 6.4 |

| 750000 | 7 | 9 | 2 | 8 | 6 | 1 | 10 | 3 | 8 | 6 | 6.0 |

| 760000 | 2 | 0 | 1 | 5 | 2 | 2 | 2 | 3 | 7 | 14 | 3.8 |

| 770000 | 0 | 0 | 7 | 5 | 10 | 10 | 9 | 6 | 1 | 7 | 5.5 |

| 780000 | 7 | 2 | 4 | 13 | 4 | 11 | 7 | 10 | 9 | 9 | 7.6 |

| 790000 | 8 | 12 | 8 | 4 | 9 | 10 | 6 | 1 | 10 | 4 | 7.2 |

| 800000 | 11 | 5 | 9 | 0 | 8 | 8 | 10 | 9 | 12 | 3 | 7.5 |

| 810000 | 4 | 2 | 10 | 10 | 10 | 5 | 4 | 10 | 5 | 7 | 6.7 |

| 820000 | 13 | 9 | 11 | 5 | 9 | 6 | 12 | 9 | 8 | 4 | 8.6 |

| 830000 | 11 | 8 | 5 | 3 | 11 | 13 | 8 | 2 | 2 | 5 | 6.8 |

| 840000 | 6 | 3 | 5 | 1 | 5 | 12 | 13 | 10 | 6 | 5 | 6.6 |

| 850000 | 5 | 6 | 13 | 4 | 10 | 9 | 10 | 5 | 1 | 8 | 7.1 |

| 860000 | 4 | 4 | 1 | 7 | 3 | 10 | 10 | 6 | 4 | 13 | 6.2 |

| 870000 | 10 | 10 | 7 | 7 | 12 | 10 | 13 | 5 | 14 | 13 | 10.1 |

| 880000 | 7 | 8 | 11 | 5 | 9 | 11 | 7 | 12 | 6 | 6 | 8.2 |

| 890000 | 12 | 5 | 2 | 8 | 6 | 6 | 3 | 0 | 6 | 1 | 4.9 |

| 900000 | 16 | 7 | 5 | 6 | 14 | 10 | 3 | 6 | 3 | 10 | 8.0 |

| 910000 | 13 | 11 | 12 | 12 | 8 | 13 | 2 | 4 | 8 | 4 | 8.7 |

| 920000 | 3 | 13 | 10 | 2 | 0 | 8 | 5 | 8 | 8 | 6 | 6.3 |

| 930000 | 12 | 10 | 5 | 13 | 9 | 11 | 10 | 8 | 6 | 7 | 9.1 |

| 940000 | 12 | 13 | 16 | 7 | 3 | 6 | 6 | 9 | 1 | 8 | 8.1 |

| 950000 | 6 | 10 | 11 | 14 | 10 | 8 | 3 | 4 | 11 | 4 | 8.1 |

| 960000 | 11 | 3 | 5 | 11 | 12 | 3 | 4 | 8 | 11 | 9 | 7.7 |

| 970000 | 15 | 9 | 7 | 6 | 1 | 10 | 11 | 12 | 9 | 10 | 9.0 |

| 980000 | 2 | 15 | 9 | 5 | 4 | 13 | 3 | 15 | 1 | 11 | 7.8 |

| 990000 | 15 | 6 | 11 | 11 | 8 | 14 | 7 | 13 | 4 | 2 | 9.1 |

| 1000000 | 10 | 12 | 14 | 7 | 10 | 4 | 12 | 7 | 5 | 9 | 9.0 |