## **Common Data Structure Operations**

| Data Structure     | Time Complexity |                   |                   |                   |           |           |           |           | Space<br>Complexity |
|--------------------|-----------------|-------------------|-------------------|-------------------|-----------|-----------|-----------|-----------|---------------------|
|                    | Average         |                   |                   |                   | Worst     |           |           |           | Worst               |
|                    | Access          | Search            | Insertion         | Deletion          | Access    | Search    | Insertion | Deletion  |                     |
| <u>Array</u>       | Θ(1)            | Θ(n)              | Θ(n)              | Θ(n)              | 0(1)      | 0(n)      | 0(n)      | 0(n)      | 0(n)                |
| <u>Stack</u>       | Θ(n)            | Θ(n)              | Θ(1)              | Θ(1)              | 0(n)      | 0(n)      | 0(1)      | 0(1)      | 0(n)                |
| <u>Queue</u>       | Θ(n)            | Θ(n)              | Θ(1)              | Θ(1)              | 0(n)      | 0(n)      | 0(1)      | 0(1)      | 0(n)                |
| Singly-Linked List | Θ(n)            | Θ(n)              | Θ(1)              | Θ(1)              | 0(n)      | 0(n)      | 0(1)      | 0(1)      | 0(n)                |
| Doubly-Linked List | Θ(n)            | Θ(n)              | Θ(1)              | Θ(1)              | 0(n)      | 0(n)      | 0(1)      | 0(1)      | 0(n)                |
| Skip List          | Θ(log(n))       | $\theta(\log(n))$ | $\theta(\log(n))$ | Θ(log(n))         | 0(n)      | 0(n)      | 0(n)      | 0(n)      | O(n log(n))         |
| Hash Table         | N/A             | Θ(1)              | Θ(1)              | Θ(1)              | N/A       | 0(n)      | 0(n)      | 0(n)      | 0(n)                |
| Binary Search Tree | Θ(log(n))       | $\theta(\log(n))$ | $\theta(\log(n))$ | $\theta(\log(n))$ | 0(n)      | 0(n)      | 0(n)      | 0(n)      | 0(n)                |
| Cartesian Tree     | N/A             | $\theta(\log(n))$ | $\theta(\log(n))$ | Θ(log(n))         | N/A       | 0(n)      | 0(n)      | 0(n)      | 0(n)                |
| B-Tree             | Θ(log(n))       | $\theta(\log(n))$ | $\theta(\log(n))$ | $\theta(\log(n))$ | O(log(n)) | O(log(n)) | O(log(n)) | O(log(n)) | 0(n)                |
| Red-Black Tree     | Θ(log(n))       | $\theta(\log(n))$ | Θ(log(n))         | Θ(log(n))         | O(log(n)) | O(log(n)) | O(log(n)) | O(log(n)) | 0(n)                |
| Splay Tree         | N/A             | $\theta(\log(n))$ | $\theta(\log(n))$ | Θ(log(n))         | N/A       | O(log(n)) | O(log(n)) | O(log(n)) | 0(n)                |
| AVL Tree           | Θ(log(n))       | $\theta(\log(n))$ | $\theta(\log(n))$ | $\theta(\log(n))$ | O(log(n)) | O(log(n)) | O(log(n)) | O(log(n)) | 0(n)                |
| KD Tree            | Θ(log(n))       | Θ(log(n))         | Θ(log(n))         | Θ(log(n))         | 0(n)      | 0(n)      | 0(n)      | 0(n)      | 0(n)                |

## **Array Sorting Algorithms**

| Algorithm        | Time Compl          | Space Complexity       |                |              |
|------------------|---------------------|------------------------|----------------|--------------|
|                  | Best                | Average                | Worst          | Worst        |
| <u>Quicksort</u> | $\Omega(n \log(n))$ | $\theta(n \log(n))$    | 0(n^2)         | $0(\log(n))$ |
| <u>Mergesort</u> | $\Omega(n \log(n))$ | $\theta(n \log(n))$    | O(n log(n))    | 0(n)         |
| <u>Timsort</u>   | Ω(n)                | $\theta(n \log(n))$    | 0(n log(n))    | 0(n)         |
| <u>Heapsort</u>  | $\Omega(n \log(n))$ | $\theta(n \log(n))$    | 0(n log(n))    | 0(1)         |
| Bubble Sort      | Ω(n)                | Θ(n^2)                 | 0(n^2)         | 0(1)         |
| Insertion Sort   | $\Omega(n)$         | Θ(n^2)                 | 0(n^2)         | 0(1)         |
| Selection Sort   | Ω(n^2)              | Θ(n^2)                 | 0(n^2)         | 0(1)         |
| Tree Sort        | $\Omega(n \log(n))$ | $\theta(n \log(n))$    | 0(n^2)         | 0(n)         |
| Shell Sort       | $\Omega(n \log(n))$ | $\theta(n(\log(n))^2)$ | 0(n(log(n))^2) | 0(1)         |
| Bucket Sort      | $\Omega(n+k)$       | $\theta(n+k)$          | 0(n^2)         | 0(n)         |
| Radix Sort       | $\Omega(nk)$        | $\Theta(nk)$           | 0(nk)          | 0(n+k)       |
| Counting Sort    | $\Omega(n+k)$       | $\theta(n+k)$          | 0(n+k)         | 0(k)         |
| <u>Cubesort</u>  | $\Omega(n)$         | $\theta(n \log(n))$    | 0(n log(n))    | 0(n)         |

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