

1. array :

Operation	Best Case Time	Average Case Time	Worst Case Time	Time Complexity Explanation	Best Case Space	Average Case Space	Worst Case Space	Space Complexity Explanation
Accessing an Element	O(1)	O(1)	O(1)	Accessing an element in an array requires constant time.	O(1)	O(1)	O(1)	Memory required to store the element is constant.
Insertion at End (Append)	O(1)	O(1) amortized	O(n)	If there's available space, insertion is constant time.	O(1)	O(1) amortized	O(n)	Resizing may require allocating a larger array.
Insertion at Beginning/Middle	O(n)	O(n)	O(n)	Requires shifting elements, which takes linear time.	O(1)	O(1)	O(n)	Resizing may require allocating a larger array.
Deletion at End	O(1)	O(1)	O(1)	Deleting from the end requires updating array length.	O(1)	O(1)	O(1)	Memory required remains constant.
Deletion at Beginning/Middle	O(n)	O(n)	O(n)	Requires shifting elements, which takes linear time.	O(1)	O(1)	O(1)	Memory required remains constant.
Copying	O(n)	O(n)	O(n)	Copying requires iterating through all elements.	O(n)	O(n)	O(n)	Memory required to store copied elements is linear.

2. string operations:

Operation	Best Case Time	Average Case Time	Worst Case Time	Time Complexity Explanation	Best Case Space	Average Case Space	Worst Case Space	Space Complexity Explanation
Accessing a Character	O(1)	O(1)	O(1)	Accessing a character in a string requires constant time.	O(1)	O(1)	O(1)	Memory required to store the character is constant.
Concatenation	O(n)	O(n)	O(n)	Concatenating two strings requires iterating through all characters.	O(n)	O(n)	O(n)	Memory required to store the concatenated string is linear.
Substring	O(1)	O(n)	O(n)	Extracting a substring requires constant time for fixed-length substrings, but linear time for variable-length substrings.	O(1)	O(n)	O(n)	Memory required to store the substring is linear.
Searching (Linear Search)	O(n)	O(n)	O(n)	Searching for a substring using linear search requires iterating through the entire string.	O(1)	O(1)	O(1)	Memory required remains constant.
Searching (Pattern Matching Algorithms)	O(n + m)	O(n + m)	O(n * m)	Pattern matching algorithms like Knuth-Morris-Pratt or Boyer-Moore have different complexities depending on the algorithm and input.	O(1)	O(1)	O(1)	Memory required remains constant.
Reversal	O(n)	O(n)	O(n)	Reversing a string requires iterating through all characters.	O(n)	O(n)	O(n)	Memory required to store the

Operation	Best Case Time	Average Case Time	Worst Case Time	Time Complexity Explanation	Best Case Space	Average Case Space	Worst Case Space	Space Complexity Explanation
								reversed string is linear.

3. linked list operations:

Operation	Best Case Time	Average Case Time	Worst Case Time	Time Complexity Explanation	Best Case Space	Average Case Space	Worst Case Space	Space Complexity Explanation
Accessing an Element	O(1)	O(n)	O(n)	Accessing an element in a linked list by index requires traversing the list.	O(1)	O(1)	O(1)	Memory required to store the accessed element is constant.
Insertion at Beginning	O(1)	O(1)	O(1)	Inserting at the beginning requires updating pointers.	O(1)	O(1)	O(1)	Memory required to store the new node is constant.
Insertion at End	O(1)	O(1)	O(1)	Inserting at the end requires updating pointers.	O(1)	O(1)	O(1)	Memory required to store the new node is constant.
Insertion in Middle	O(1)	O(n)	O(n)	Inserting in the middle requires traversing to the insertion point.	O(1)	O(1)	O(1)	Memory required to store the new node is constant.
Deletion at Beginning	O(1)	O(1)	O(1)	Deleting from the beginning requires updating pointers.	O(1)	O(1)	O(1)	Memory required remains constant.
Deletion at End	O(1)	O(n)	O(n)	Deleting from the end requires traversing to the end of the list.	O(1)	O(1)	O(1)	Memory required remains constant.
Deletion in Middle	O(1)	O(n)	O(n)	Deleting in the middle requires traversing to the deletion point.	O(1)	O(1)	O(1)	Memory required remains constant.
Searching (Linear Search)	O(n)	O(n)	O(n)	Searching for an element using linear search requires traversing the list.	O(1)	O(1)	O(1)	Memory required remains constant.
Reversal	O(n)	O(n)	O(n)	Reversing a linked list requires iterating through all nodes.	O(n)	O(n)	O(n)	Memory required to store the reversed list is linear.
Copying	O(n)	O(n)	O(n)	Copying a linked list requires iterating through all nodes.	O(n)	O(n)	O(n)	Memory required to store the copied list is linear.

4. stack operations:

Operation	Best Case Time	Average Case Time	Worst Case Time	Time Complexity Explanation	Best Case Space	Average Case Space	Worst Case Space	Space Complexity Explanation
Push	O(1)	O(1)	O(1)	Pushing an element onto a stack requires constant time.	O(1)	O(1)	O(1)	Memory required to store the pushed element is constant.
Pop	O(1)	O(1)	O(1)	Popping an element from a stack requires constant time.	O(1)	O(1)	O(1)	Memory required remains constant.

Operation	Best Case Time	Average Case Time	Worst Case Time	Time Complexity Explanation	Best Case Space	Average Case Space	Worst Case Space	Space Complexity Explanation
Peek (Top)	O(1)	O(1)	O(1)	Retrieving the top element of a stack requires constant time.	O(1)	O(1)	O(1)	Memory required remains constant.
Search	O(n)	O(n)	O(n)	Searching for an element in a stack requires linear time.	O(1)	O(1)	O(1)	Memory required remains constant.
Size	O(1)	O(1)	O(1)	Determining the size of a stack requires constant time.	O(1)	O(1)	O(1)	Memory required remains constant.
Copying	O(n)	O(n)	O(n)	Copying a stack requires iterating through all elements.	O(n)	O(n)	O(n)	Memory required to store the copied stack is linear.

5. queue operations:

Operation	Best Case Time	Average Case Time	Worst Case Time	Time Complexity Explanation	Best Case Space	Average Case Space	Worst Case Space	Space Complexity Explanation
Enqueue	O(1)	O(1)	O(1)	Enqueuing an element into a queue requires constant time.	O(1)	O(1)	O(1)	Memory required to store the enqueued element is constant.
Dequeue	O(1)	O(1)	O(1)	Dequeuing an element from a queue requires constant time.	O(1)	O(1)	O(1)	Memory required remains constant.
Peek (Front)	O(1)	O(1)	O(1)	Retrieving the front element of a queue requires constant time.	O(1)	O(1)	O(1)	Memory required remains constant.
Search	O(n)	O(n)	O(n)	Searching for an element in a queue requires linear time.	O(1)	O(1)	O(1)	Memory required remains constant.
Size	O(1)	O(1)	O(1)	Determining the size of a queue requires constant time.	O(1)	O(1)	O(1)	Memory required remains constant.
Copying	O(n)	O(n)	O(n)	Copying a queue requires iterating through all elements.	O(n)	O(n)	O(n)	Memory required to store the copied queue is linear.

6.binary tree operations:

Operation	Best Case Time	Average Case Time	Worst Case Time	Time Complexity Explanation	Best Case Space	Average Case Space	Worst Case Space	Space Complexity Explanation
Search	O(1)	O(log n)	O(n)	Searching for an element in a binary tree.	O(1)	O(1)	O(1)	Memory required remains constant. (Assuming no additional data structure)
Insertion	O(1)	O(log n)	O(n)	Inserting an element into a binary tree.	O(1)	O(1)	O(1)	Memory required remains constant. (Assuming no additional data structure)
Deletion	O(1)	O(log n)	O(n)	Deleting an element from a	O(1)	O(1)	O(1)	Memory required remains constant.

Operation	Best Case Time	Average Case Time	Worst Case Time	Time Complexity Explanation	Best Case Space	Average Case Space	Worst Case Space	Space Complexity Explanation
				binary tree.				(Assuming no additional data structure)
Traversal (Inorder, Preorder, Postorder)	O(n)	O(n)	O(n)	Traversing all nodes of a binary tree.	O(n)	O(n)	O(n)	Memory required to store the traversal result is linear.
Height	O(1)	O(log n)	O(n)	Determining the height of a binary tree.	O(1)	O(1)	O(1)	Memory required remains constant.
Copying	O(n)	O(n)	O(n)	Copying a binary tree.	O(n)	O(n)	O(n)	Memory required to store the copied binary tree is linear.

7. binary search tree (BST) operations:

Operation	Best Case Time	Average Case Time	Worst Case Time	Time Complexity Explanation	Best Case Space	Average Case Space	Worst Case Space	Space Complexity Explanation
Search	O(1)	O(log n)	O(n)	Searching for an element in a binary search tree.	O(1)	O(1)	O(1)	Memory required remains constant. (Assuming no additional data structure)
Insertion	O(1)	O(log n)	O(n)	Inserting an element into a binary search tree.	O(1)	O(1)	O(1)	Memory required remains constant. (Assuming no additional data structure)
Deletion	O(1)	O(log n)	O(n)	Deleting an element from a binary search tree.	O(1)	O(1)	O(1)	Memory required remains constant. (Assuming no additional data structure)
Traversal (Inorder, Preorder, Postorder)	O(n)	O(n)	O(n)	Traversing all nodes of a binary search tree.	O(n)	O(n)	O(n)	Memory required to store the traversal result is linear.
Minimum/Maximum	O(1)	O(log n)	O(n)	Finding the minimum or maximum element in a binary search tree.	O(1)	O(1)	O(1)	Memory required remains constant.
Successor/Predecessor	O(1)	O(log n)	O(n)	Finding the successor or predecessor of an element in a binary search tree.	O(1)	O(1)	O(1)	Memory required remains constant.
Height	O(1)	O(log n)	O(n)	Determining the height of a binary search tree.	O(1)	O(1)	O(1)	Memory required remains constant.
Copying	O(n)	O(n)	O(n)	Copying a binary search tree.	O(n)	O(n)	O(n)	Memory required to store the copied

Operation	Best Case Time	Average Case Time	Worst Case Time	Time Complexity Explanation	Best Case Space	Average Case Space	Worst Case Space	Space Complexity Explanation
								binary search tree is linear.

8. operations on 2D arrays:

Operation	Best Case Time	Average Case Time	Worst Case Time	Time Complexity Explanation	Best Case Space	Average Case Space	Worst Case Space	Space Complexity Explanation
Accessing an Element	O(1)	O(1)	O(1)	Accessing an element in a 2D array requires constant time.	O(1)	O(1)	O(1)	Memory required to store the accessed element is constant.
Insertion at End (Row Append)	O(1)	O(1)	O(1)	Inserting a row at the end of a 2D array requires constant time.	O(1)	O(1)	O(1)	Memory required remains constant.
Insertion at Beginning (Row Prepend)	O(n)	O(n)	O(n)	Inserting a row at the beginning of a 2D array requires shifting elements, which takes linear time.	O(1)	O(n)	O(n)	Memory required remains constant.
Deletion of Row	O(1)	O(n)	O(n)	Deleting a row from a 2D array requires shifting elements, which takes linear time.	O(1)	O(n)	O(n)	Memory required remains constant.
Insertion at End (Column Append)	O(1)	O(m)	O(m)	Inserting a column at the end of a 2D array requires updating each row, which takes linear time.	O(m)	O(m)	O(m)	Memory required increases linearly with the number of columns.
Insertion at Beginning (Column Prepend)	O(n)	O(n * m)	O(n * m)	Inserting a column at the beginning of a 2D array requires shifting elements, which takes linear time.	O(n * m)	O(n * m)	O(n * m)	Memory required increases linearly with the size of the array.
Deletion of Column	O(1)	O(n * m)	O(n * m)	Deleting a column from a 2D array requires updating each row, which takes linear time.	O(n * m)	O(n * m)	O(n * m)	Memory required remains constant.
Searching (Linear Search)	O(n * m)	O(n * m)	O(n * m)	Searching for an element using linear search requires traversing the entire array.	O(1)	O(1)	O(1)	Memory required remains constant.
Searching (Binary Search)	O(n * log m)	O(n * log m)	O(n * log m)	Searching for an element using binary search requires a sorted array, so preprocessing may be needed.	O(1)	O(1)	O(1)	Memory required remains constant.
Sorting (Row-wise)	O(n * m * log m)	O(n * m * log m)	O(n * m * log m)	Sorting each row of a 2D array using an efficient sorting algorithm like Quick Sort or Merge Sort.	O(1)	O(1)	O(1)	Memory required remains constant.
Sorting (Column-wise)	O(n * log n * m)	O(n * log n * m)	O(n * log n * m)	Sorting each column of a 2D array using an efficient sorting algorithm like Quick Sort or Merge Sort.	O(1)	O(1)	O(1)	Memory required remains constant.
Copying	O(n * m)	O(n * m)	O(n * m)	Copying a 2D array requires iterating through all	O(n * m)	O(n * m)	O(n * m)	Memory required to store the copied



Operation	Best Case Time	Average Case Time	Worst Case Time	Time Complexity Explanation	Best Case Space	Average Case Space	Worst Case Space	Space Complexity Explanation
				elements.				array is linear.

9.operations on a hash set:

Operation	Best Case Time	Average Case Time	Worst Case Time	Time Complexity Explanation	Best Case Space	Average Case Space	Worst Case Space	Space Complexity Explanation
Insertion	O(1)	O(1)	O(n)	Inserting an element into a hash set.	O(1)	O(1)	O(n)	Memory required remains constant, but can increase due to resizing.
Deletion	O(1)	O(1)	O(n)	Deleting an element from a hash set.	O(1)	O(1)	O(n)	Memory required remains constant, but can increase due to resizing.
Search	O(1)	O(1)	O(n)	Searching for an element in a hash set.	O(1)	O(1)	O(n)	Memory required remains constant, but can increase due to resizing.
Copying	O(n)	O(n)	O(n)	Copying a hash set.	O(n)	O(n)	O(n)	Memory required to store the copied hash set is linear.

10.operations on a hash map (hash table):

Operation	Best Case Time	Average Case Time	Worst Case Time	Time Complexity Explanation	Best Case Space	Average Case Space	Worst Case Space	Space Complexity Explanation
Insertion	O(1)	O(1)	O(n)	Inserting a key-value pair into a hash map.	O(1)	O(1)	O(n)	Memory required remains constant, but can increase due to resizing.
Deletion	O(1)	O(1)	O(n)	Deleting a key-value pair from a hash map.	O(1)	O(1)	O(n)	Memory required remains constant, but can increase due to resizing.
Search	O(1)	O(1)	O(n)	Searching for a key in a hash map.	O(1)	O(1)	O(n)	Memory required remains constant, but can increase due to resizing.
Accessing an Element	O(1)	O(1)	O(n)	Accessing a value by key in a hash map.	O(1)	O(1)	O(n)	Memory required remains constant, but can increase due to resizing.
Copying	O(n)	O(n)	O(n)	Copying a hash map.	O(n)	O(n)	O(n)	Memory required to store the copied hash map is linear.

9. operations on a trie:

Operation	Best Case Time	Average Case Time	Worst Case Time	Time Complexity Explanation	Best Case Space	Average Case Space	Worst Case Space	Space Complexity Explanation
Insertion	O(1)	O(m)	O(m)	Inserting a word into a trie, where m is the length of the word.	O(1)	O(m)	O(m)	Memory required increases linearly with the length of the word.

Operation	Best Case Time	Average Case Time	Worst Case Time	Time Complexity Explanation	Best Case Space	Average Case Space	Worst Case Space	Space Complexity Explanation
Deletion	O(1)	O(m)	O(m)	Deleting a word from a trie, where m is the length of the word.	O(1)	O(m)	O(m)	Memory required remains constant, but can increase due to resizing.
Search	O(1)	O(m)	O(m)	Searching for a word in a trie, where m is the length of the word.	O(1)	O(1)	O(1)	Memory required remains constant.
Prefix Search	O(1)	O(k)	O(k)	Finding all words with a given prefix, where k is the length of the prefix.	O(1)	O(1)	O(1)	Memory required remains constant.
Copying	O(n)	O(n)	O(n)	Copying a trie.	O(n)	O(n)	O(n)	Memory required to store the copied trie is linear.

10. operations on a hash table:

Operation	Best Case Time	Average Case Time	Worst Case Time	Time Complexity Explanation	Best Case Space	Average Case Space	Worst Case Space	Space Complexity Explanation
Insertion	O(1)	O(1)	O(n)	Inserting an element into a hash table.	O(1)	O(1)	O(n)	Memory required remains constant, but can increase due to resizing.
Deletion	O(1)	O(1)	O(n)	Deleting an element from a hash table.	O(1)	O(1)	O(n)	Memory required remains constant, but can increase due to resizing.
Search	O(1)	O(1)	O(n)	Searching for an element in a hash table.	O(1)	O(1)	O(n)	Memory required remains constant, but can increase due to resizing.
Accessing an Element	O(1)	O(1)	O(n)	Accessing a value by key in a hash table.	O(1)	O(1)	O(n)	Memory required remains constant, but can increase due to resizing.
Copying	O(n)	O(n)	O(n)	Copying a hash table.	O(n)	O(n)	O(n)	Memory required to store the copied hash table is linear.

11.operations on an ArrayList:

Operation	Best Case Time	Average Case Time	Worst Case Time	Time Complexity Explanation	Best Case Space	Average Case Space	Worst Case Space	Space Complexity Explanation
Accessing an Element	O(1)	O(1)	O(1)	Accessing an element in an ArrayList by index.	O(1)	O(1)	O(1)	Memory required to store the accessed element is constant.
Insertion at End (Append)	O(1)	O(1)	O(n)	Inserting an element at the end of an ArrayList.	O(1)	O(1)	O(n)	Memory required remains constant, but can increase due to resizing.
Insertion at Beginning	O(n)	O(n)	O(n)	Inserting an element at the beginning of	O(1)	O(n)	O(n)	Memory required remains constant, but

Operation	Best Case Time	Average Case Time	Worst Case Time	Time Complexity Explanation	Best Case Space	Average Case Space	Worst Case Space	Space Complexity Explanation
				an ArrayList.				can increase due to resizing.
Insertion in Middle	O(n)	O(n)	O(n)	Inserting an element in the middle of an ArrayList.	O(1)	O(n)	O(n)	Memory required remains constant, but can increase due to resizing.
Deletion at End	O(1)	O(1)	O(1)	Deleting an element from the end of an ArrayList.	O(1)	O(1)	O(1)	Memory required remains constant.
Deletion at Beginning	O(n)	O(n)	O(n)	Deleting an element from the beginning of an ArrayList.	O(1)	O(n)	O(n)	Memory required remains constant, but can increase due to resizing.
Deletion in Middle	O(n)	O(n)	O(n)	Deleting an element from the middle of an ArrayList.	O(1)	O(n)	O(n)	Memory required remains constant, but can increase due to resizing.
Copying	O(n)	O(n)	O(n)	Copying an ArrayList.	O(n)	O(n)	O(n)	Memory required to store the copied ArrayList is linear.

12. divide and conquer algorithm:

Operation	Best Case Time	Average Case Time	Worst Case Time	Time Complexity Explanation	Best Case Space	Average Case Space	Worst Case Space	Space Complexity Explanation
Divide	O(1)	O(1)	O(1)	Dividing the problem into subproblems.	O(1)	O(1)	O(1)	Memory required remains constant.
Conquer	O(1)	O(n log n)	O(n^2)	Solving each subproblem recursively.	O(1)	O(1)	O(1)	Memory required remains constant.
Merge (if applicable)	O(n)	O(n)	O(n)	Merging the solutions of subproblems.	O(n)	O(n)	O(n)	Memory required linearly depends on the size of the solution.

13.complexities for hashing:

Operation	Best Case Time	Average Case Time	Worst Case Time	Time Complexity Explanation	Best Case Space	Average Case Space	Worst Case Space	Space Complexity Explanation
Insertion	O(1)	O(1)	O(n)	Inserting an element into a hash table.	O(1)	O(1)	O(n)	Memory required remains constant, but can increase due to collisions or resizing.
Deletion	O(1)	O(1)	O(n)	Deleting an element from a hash table.	O(1)	O(1)	O(n)	Memory required remains constant, but can increase due to collisions or resizing.
Search	O(1)	O(1)	O(n)	Searching for an element in a hash table.	O(1)	O(1)	O(n)	Memory required remains constant, but can increase due to collisions or resizing.

13. generic greedy algorithm:



Operation	Best Case Time	Average Case Time	Worst Case Time	Time Complexity Explanation	Best Case Space	Average Case Space	Worst Case Space	Space Complexity Explanation
Greedy Algorithm	O(n)	O(n)	O(n)	Solving the problem using a greedy strategy.	O(1)	O(1)	O(1)	Memory required remains constant.

14. generic backtracking algorithm:

Operation	Best Case Time	Average Case Time	Worst Case Time	Time Complexity Explanation	Best Case Space	Average Case Space	Worst Case Space	Space Complexity Explanation
Backtracking Algorithm	O(1)	O(b^d)	O(b^d)	Solving the problem using backtracking, where b is the branching factor and d is the depth of the search tree.	O(d)	O(d)	O(d)	Memory required increases with the depth of the recursive calls.

15. tree traversal algorithms:

Operation	Best Case Time	Average Case Time	Worst Case Time	Time Complexity Explanation	Best Case Space	Average Case Space	Worst Case Space	Space Complexity Explanation
Depth-First Traversal	O(n)	O(n)	O(n)	Visiting each node once using a depth-first traversal algorithm.	O(h)	O(h)	O(h)	Memory required is proportional to the height of the tree.
Breadth-First Traversal	O(n)	O(n)	O(n)	Visiting each node once using a breadth-first traversal algorithm.	O(w)	O(w)	O(w)	Memory required is proportional to the maximum width of the tree (w).

17.dynamic programming algorithms:

Operation	Best Case Time	Average Case Time	Worst Case Time	Time Complexity Explanation	Best Case Space	Average Case Space	Worst Case Space	Space Complexity Explanation
Dynamic Programming	O(n)	O(n * m)	O(n * m)	Solving the problem using dynamic programming, where n and m represent the size of input data or dimensions of the problem space.	O(n * m)	O(n * m)	O(n * m)	Memory required is proportional to the size of the problem space or dimensions of the problem.

16. AVL tree:

Operation	Best Case Time	Average Case Time	Worst Case Time	Time Complexity Explanation	Best Case Space	Average Case Space	Worst Case Space	Space Complexity Explanation
Search	O(log n)	O(log n)	O(log n)	Searching for an element in an AVL tree.	O(1)	O(1)	O(1)	Memory required remains constant.
Insertion	O(log n)	O(log n)	O(log n)	Inserting an element into an AVL tree.	O(1)	O(1)	O(1)	Memory required remains constant.
Deletion	O(log n)	O(log n)	O(log n)	Deleting an element from an AVL tree.	O(1)	O(1)	O(1)	Memory required remains constant.

Operation	Best Case Time	Average Case Time	Worst Case Time	Time Complexity Explanation	Best Case Space	Average Case Space	Worst Case Space	Space Complexity Explanation
Traversal (Inorder, Preorder, Postorder)	$O(n)$	$O(n)$	$O(n)$	Traversing all nodes of an AVL tree.	$O(n)$	$O(n)$	$O(n)$	Memory required to store the traversal result is linear.
Minimum/Maximum	$O(\log n)$	$O(\log n)$	$O(\log n)$	Finding the minimum or maximum element in an AVL tree.	$O(1)$	$O(1)$	$O(1)$	Memory required remains constant.
Successor/Predecessor	$O(\log n)$	$O(\log n)$	$O(\log n)$	Finding the successor or predecessor of an element in an AVL tree.	$O(1)$	$O(1)$	$O(1)$	Memory required remains constant.
Height	$O(1)$	$O(1)$	$O(1)$	Determining the height of an AVL tree.	$O(1)$	$O(1)$	$O(1)$	Memory required remains constant.
Copying	$O(n)$	$O(n)$	$O(n)$	Copying an AVL tree.	$O(n)$	$O(n)$	$O(n)$	Memory required to store the copied AVL tree is linear.