

### Arrays & Strings

Stores data elements based on an sequential, most commonly 0 based, index.

#### Time Complexity

- **Indexing:** Linear array:  $O(1)$ , Dynamic array:  $O(1)$
- **Search:** Linear array:  $O(n)$ , Dynamic array:  $O(n)$
- **Optimized Search:** Linear array:  $O(\log n)$ , Dynamic array:  $O(\log n)$
- **Insertion:** Linear array:  $n/a$ , Dynamic array:  $O(n)$

#### Bonus:

- `type[] name = {val1, val2, ...}`
- `Arrays.sort(arr) ->  $O(n \log n)$`
- `Collections.sort(list) ->  $O(n \log n)$`
- `int digit = '4' - '0' -> 4`
- `String s = String.valueOf('e') -> "e"`
- `(int) 'a' -> 97 (ASCII)`
- `new String(char[] arr) ['a','e'] -> "ae"`
- `(char) ('a' + 1) -> 'b'`
- `Character.isLetterOrDigit(char) -> true/false`
- `new ArrayList<>(anotherList); -> list w/ items`
- `StringBuilder.append(char|String)`

### Linked List

Stores data with nodes that point to other nodes.

#### Time Complexity

- **Indexing:**  $O(n)$
- **Search:**  $O(n)$
- **Optimized Search:**  $O(n)$
- **Append:**  $O(1)$
- **Prepend:**  $O(1)$
- **Insertion:**  $O(n)$

### HashTable

Stores data with key-value pairs.

#### Time Complexity

- **Indexing:**  $O(1)$
- **Search:**  $O(1)$
- **Insertion:**  $O(1)$

#### Bonus:

- `{1, -1, 0, 2, -2}` into map
- `HashMap {-1, 0, 2, 1, -2} -> any order`
- `LinkedHashMap {1, -1, 0, 2, -2} -> insertion order`
- `TreeMap {-2, -1, 0, 1, 2} -> sorted`
- Set doesn't allow duplicates.
- `map.getOrDefaultValue(key, default value)`

### Stack/Queue/Deque

Stack	Queue	Deque	Heap
Last In First Out	First In Last Out	Provides first/last	Ascending Order
<code>push(val)</code>	<code>offer(val)</code>	<code>offer(val)</code>	<code>offer(val)</code>
<code>pop()</code>	<code>poll()</code>	<code>poll()</code>	<code>poll()</code>
<code>peek()</code>	<code>peek()</code>	<code>peek()</code>	<code>peek()</code>

Implementation in Java:

- `Stack<E> stack = new Stack();`
- `Queue<E> queue = new LinkedList();`
- `Deque<E> deque = new LinkedList();`
- `PriorityQueue<E> pq = new PriorityQueue();`

### DFS & BFS Big O Notation

	Time	Space
<b>DFS</b>	$O(E+V)$	$O(\text{Height})$
<b>BFS</b>	$O(E+V)$	$O(\text{Length})$

**V & E** -> where V is the number of vertices and E is the number of edges.

**Height** -> where h is the maximum height of the tree.

**Length** -> where l is the maximum number of nodes in a single level.

### DFS vs BFS

DFS	BFS
● Better when target is closer to Source.	● Better when target is far from Source.
● Stack -> LIFO	● Queue -> FIFO
● Preorder, Inorder, Postorder Search	● Level Order Search
● Goes deep	● Goes wide
● Recursive	● Iterative
● Fast	● Slow



### BFS Impl for Graph

```
public boolean connected(int[][] graph, int start,
int end) {
    Set<Integer> visited = new HashSet<>();
    Queue<Integer> toVisit = new LinkedList<>();
    toVisit.enqueue(start);
    while (!toVisit.isEmpty()) {
        int curr = toVisit.dequeue();
        if (visited.contains(curr)) continue;
        if (curr == end) return true;
        for (int i : graph[start]) {
            toVisit.enqueue(i);
        }
        visited.add(curr);
    }
    return false;
}
```

### DFS Impl for Graph

```
public boolean connected(int[][] graph, int start,
int end) {
    Set<Integer> visited = new HashSet<>();
    return connected(graph, start, end, visited);
}
private boolean connected(int[][] graph, int start,
int end, Set<Integer> visited) {
    if (start == end) return true;
    if (visited.contains(start)) return false;
    visited.add(start);
    for (int i : graph[start]) {
        if (connected(graph, i, end, visited)) {
            return true;
        }
    }
    return false;
}
```

### BFS Impl. for Level-order Tree Traversal

```
private void printLevelOrder(TreeNode root) {
    Queue<TreeNode> queue = new LinkedList<>();
    queue.offer(root);
    while (!queue.isEmpty()) {
        TreeNode tempNode = queue.poll();
        print(tempNode.data + " ");

        //add left child
        if (tempNode.left != null) {
            queue.offer(tempNode.left);
        }

        //add right child
        if (tempNode.right != null) {
            queue.offer(tempNode.right);
        }
    }
}
```

### DFS Impl. for In-order Tree Traversal

```
private void inorder(TreeNode root) {
    if (root == null)
        return;
    // Traverse left
    inorder(root.left);
    // Traverse root
    print(root.data + " ");
    // Traverse right
    inorder(root.right);
}
```



### Dynamic Programming

- Dynamic programming is the technique of storing repeated computations in memory, rather than recomputing them every time you need them.
- The ultimate goal of this process is to improve runtime.
- Dynamic programming allows you to use more space to take less time.

### Dynamic Programming Patterns

- Minimum (Maximum) Path to Reach a Target

#### Approach:

Choose minimum (maximum) path among all possible paths before the current state, then add value for the current state.

#### Formula:

$routes[i] = \min(routes[i-1], routes[i-2], \dots, routes[i-k]) + cost[i]$

- Distinct Ways

#### Approach:

Choose minimum (maximum) path among all possible paths before the current state, then add value for the current state.

#### Formula:

$routes[i] = routes[i-1] + routes[i-2], \dots, + routes[i-k]$

- Merging Intervals

#### Approach:

Find all optimal solutions for every interval and return the best possible answer

#### Formula:

$dp[i][j] = dp[i][k] + result[k] + dp[k+1][j]$

- DP on Strings

#### Approach:

Compare 2 chars of String or 2 Strings. Do whatever you do. Return.

#### Formula:

if  $s1[i-1] == s2[j-1]$  then  $dp[i][j] = //code$ .

Else  $dp[i][j] = //code$

- Decision Making

#### Approach:

If you decide to choose the current value use the previous result where the value was ignored; vice-versa, if you decide to ignore the current value use previous result where value was used.

#### Formula:

$dp[i][j] = \max(\{dp[i][j], dp[i-1][j] + arr[i], dp[i-1][j-1]\});$

$dp[i][j-1] = \max(\{dp[i][j-1], dp[i-1][j-1] + arr[i], arr[i]\});$

### Binary Search Big O Notation

	Time	Space
Binary Search	$O(\log n)$	$O(1)$

### Binary Search - Recursive

```
public int binarySearch(int search, int[] array,
    int start, int end) {
    int middle = start + ((end - start) / 2);
    if(end < start) {
        return -1;
    }
    if (search == array[middle]) {
        return middle;
    } else if (search < array[middle]) {
        return binarySearch(search, array, start,
            middle - 1);
    } else {
        return binarySearch(search, array, middle +
            1, end);
    }
}
```

### Binary Search - Iterative

```
public int binarySearch(int target, int[] array) {
    int start = 0;
    int end = array.length - 1;
    while (start <= end) {
        int middle = start + ((end - start) / 2);
        if (target == array[middle]) {
            return target;
        } else if (search < array[middle]) {
            end = middle - 1;
        } else {
            start = middle + 1;
        }
    }
}
```



### Binary Search - Iterative (cont)

```
return -1;
}
```

### Bit Manipulation

Sign Bit      0 -> Positive, 1 -> Negative

AND            0 & 0 -> 0  
                  0 & 1 -> 0  
                  1 & 1 -> 1

OR             0 | 0 -> 0  
                  0 | 1 -> 1  
                  1 | 1 -> 1

XOR            0 ^ 0 -> 0  
                  0 ^ 1 -> 1  
                  1 ^ 1 -> 0

INVERT        ~ 0 -> 1  
                  ~ 1 -> 0

#### Bonus:

##### • Shifting

- Left Shift

0001 << 0010 (Multiply by 2)

- Right Shift

0010 >> 0001 (Division by 2)

##### • Count 1's of n, Remove last bit

$n = n \& (n-1);$

##### • Extract last bit

$n \& -n$  or  $n \& \sim(n-1)$  or  $n \wedge (n \& (n-1))$

•  $n \wedge n -> 0$

•  $n \wedge 0 -> n$

### Sorting Big O Notation

	Best	Average	Space
<b>Merge Sort</b>	$O(n \log(n))$	$O(n \log(n))$	$O(n)$
<b>Heap Sort</b>	$O(n \log(n))$	$O(n \log(n))$	$O(1)$
<b>Quick Sort</b>	$O(n \log(n))$	$O(n \log(n))$	$O(\log(n))$
<b>Insertion Sort</b>	$O(n)$	$O(n^2)$	$O(1)$
<b>Selection Sort</b>	$O(n^2)$	$O(n^2)$	$O(1)$
<b>Bubble Sort</b>	$O(n)$	$O(n^2)$	$O(1)$

### Merge Sort

```
private void mergesort(int low, int high) {
    if (low < high) {
        int middle = low + (high - low) / 2;
        mergesort(low, middle);
        mergesort(middle + 1, high);
        merge(low, middle, high);
    }
}

private void merge(int low, int middle, int high)
{
    for (int i = low; i <= high; i++) {
        helper[i] = numbers[i];
    }

    int i = low;
    int j = middle + 1;
    int k = low;

    while (i <= middle && j <= high) {
        if (helper[i] <= helper[j]) {
            numbers[k] = helper[i];
            i++;
        } else {
            numbers[k] = helper[j];
            j++;
        }
        k++;
    }

    while (i <= middle) {
        numbers[k] = helper[i];
        k++;
        i++;
    }
}
```

### Quick Sort

```
private void quicksort(int low, int high) {
    int i = low, j = high;
    int pivot = numbers[low + (high-low)/2];
    while (i <= j) {
        while (numbers[i] < pivot) {
            i++;
        }
        while (numbers[j] > pivot) {
            j--;
        }
        if (i <= j) {
            exchange(i, j);
            i++;
            j--;
        }
    }
    if (low < j)
        quicksort(low, j);
    if (i < high)
        quicksort(i, high);
}
```

---



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### Insertion Sort

```
void insertionSort(int arr[]) {
    int n = arr.length;
    for (int i = 1; i < n; ++i) {
        int key = arr[i];
        int j = i - 1;
        while (j >= 0 && arr[j] > key) {
            arr[j + 1] = arr[j];
            j = j - 1;
        }
        arr[j + 1] = key;
    }
}
```

### Combinations Backtrack Pattern

#### - Combination

```
public List<List<Integer>> combinationSum(int[]
nums, int target) {
    List<List<Integer>> list = new ArrayList<>();
    Arrays.sort(nums);
    backtrack(list, new ArrayList<>(), nums,
target, 0);
    return list;
}

private void backtrack(List<List<Integer>> list,
List<Integer> tempList, int [] nums, int remain,
int start){
    if(remain < 0) return;
    else if(remain == 0) list.add(new ArrayList<>
(tempList));
    else{
        for(int i = start; i < nums.length; i++){
            tempList.add(nums[i]);
            // not i + 1 because we can reuse
same elements
            backtrack(list, tempList, nums, remain
- nums[i], i);
            // not i + 1 because we can reuse
same elements
            tempList.remove(tempList.size() - 1);
```

### Combinations Backtrack Pattern (cont)

```
    }
}
}
```

### Palindrome Backtrack Pattern

#### - Palindrome Partitioning

```
public List<List<String>> partition(String s) {
    List<List<String>> list = new ArrayList<>();
    backtrack(list, new ArrayList<>(), s, 0);
    return list;
}

public void backtrack(List<List<String>> list,
List<String> tempList, String s, int start){
    if(start == s.length())
        list.add(new ArrayList<>(tempList));
    else{
        for(int i = start; i < s.length(); i++){
            if(isPalindrome(s, start, i)){
                tempList.add(s.substring(start, i +
1));
                backtrack(list, tempList, s, i + 1);
                tempList.remove(tempList.size() - 1);
            }
        }
    }
}
```

### Subsets Backtrack Pattern

#### - Subsets

```
public List<List<Integer>> subsets(int[] nums) {
    List<List<Integer>> list = new ArrayList<>();
    Arrays.sort(nums);
    backtrack(list, new ArrayList<>(), nums, 0);
    return list;
```



### Subsets Backtrack Pattern (cont)

```

}
private void backtrack(List<List<Integer>> list,
List<Integer> tempList, int [] nums, int start){
    list.add(new ArrayList<>(tempList));
    for(int i = start; i < nums.length; i++){
        // skip duplicates
        if(i > start && nums[i] == nums[i-1])
            continue;
        // skip duplicates
        tempList.add(nums[i]);
        backtrack(list, tempList, nums, i + 1);
        tempList.remove(tempList.size() - 1);
    }
}

```

### Permutations Backtrack Pattern (cont)

```

}
}
}

```

### Permutations Backtrack Pattern

```

- Permutations
public List<List<Integer>> permute(int[] nums) {
    List<List<Integer>> list = new ArrayList<>();
    // Arrays.sort(nums); // not necessary
    backtrack(list, new ArrayList<>(), nums);
    return list;
}
private void backtrack(List<List<Integer>> list,
List<Integer> tempList, int [] nums){
    if(tempList.size() == nums.length){
        list.add(new ArrayList<>(tempList));
    } else{
        for(int i = 0; i < nums.length; i++){
            // element already exists, skip
            if(tempList.contains(nums[i])) continue;
            // element already exists, skip
            tempList.add(nums[i]);
            backtrack(list, tempList, nums);
            tempList.remove(tempList.size() - 1);
        }
    }
}

```



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