JavaScript Data Structures & Algorithms

Essential Cheat Sheet

```
class Node {
  constructor(value) {
    this.value = value;
    this.next = null;
  }
}
```

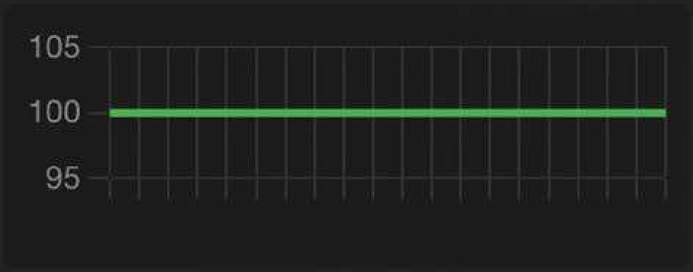
Swipe for more >>

Big O Notation

Time Complexity Analysis

O(1)

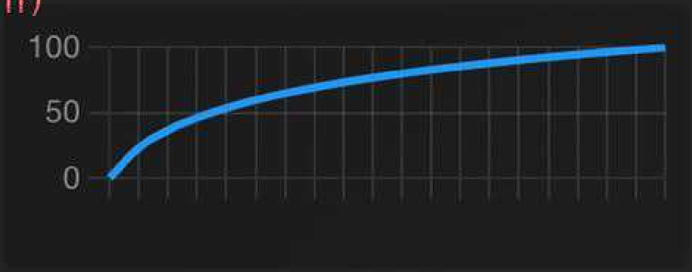
Constant Time



Always takes same time regardless of input size. Like accessing array index.

O(log n)

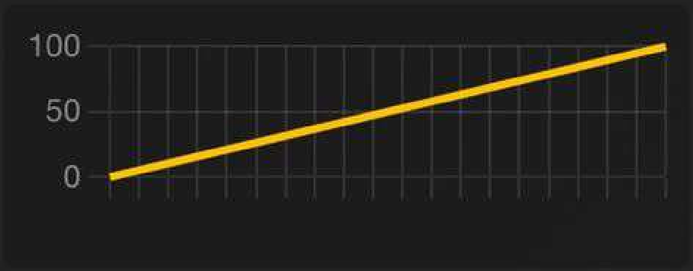
Logarithmic Time



Cuts problem in half each time. Like binary search.

O(n)

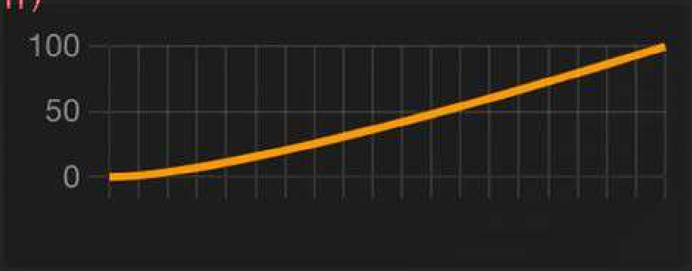
Linear Time



Time grows linearly with input. Like linear search.

O(n log n)

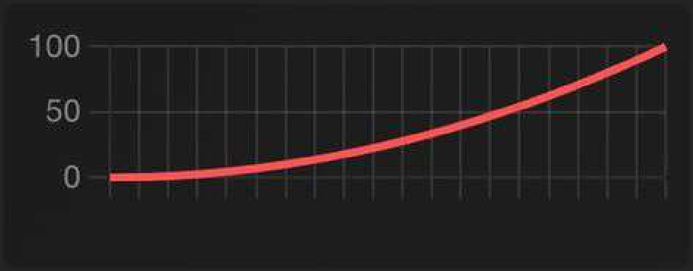
Linearithmic Time



Common in efficient sorting algorithms like merge sort.

O(n^2)

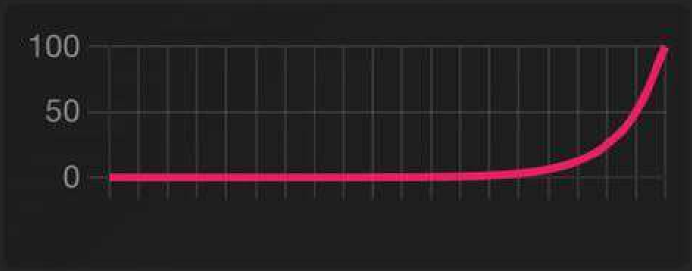
Quadratic Time



Nested iterations. Like bubble sort.

O(2^n)

Exponential Time



Solutions double with each addition. Like recursive fibonacci.

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Arrays

Common Operations & Time Complexity

Access

O(1)

Get or set element directly using index position. Fastest array operation.

```
const value = array[5];
```

Push/Pop

O(1)

Add (push) or remove (pop) element at end. Efficient as no reindexing needed.

```
array.push(1); // add
array.pop();    // remove
```

Unshift/Shift

O(n)

Add (unshift) or remove (shift) at start. Requires reindexing all elements.

```
array.unshift(1); // add
array.shift();     // remove
```

Search

O(n)

Find element by value. Must check each element until match found.

```
array.indexOf(5);
array.find(x => x > 3);
```

Insert

O(n)

Insert at position. Requires shifting all subsequent elements right.

```
array.splice(2, 0, 5);
```

Delete

O(n)

Remove at position. Requires shifting all subsequent elements left.

```
array.splice(2, 1);
```

Linked List

Linear Data Structure

Insert Head

O(1)

Add new node at beginning. Just update head pointer.

```
node.next = head;
head = node;
```

Insert Tail

O(1)*

Add at end with tail pointer. O(n) without tail.

```
tail.next = node;
tail = node;
```

Delete Head

O(1)

Remove first node. Update head pointer.

```
head = head.next;
```

Insert/Delete Middle

O(n)

Need to traverse to find position first.

```
prev.next = node;
node.next = current;
```

Search

O(n)

Must traverse nodes sequentially.

```
while(current) {
  if(current.val === x) return true;
  current = current.next;
}
```

Access by Index

O(n)

No direct access. Must traverse from start.

```
for(let i = 0; i < index; i++) {
  current = current.next;
}
```

Binary Trees

Common Operations

Insert

O(log n)*

Add new node in BST. O(n) worst case for unbalanced.

```
if (value < node.val)
  node.left = insert(node.left, value);
else
  node.right = insert(node.right, value);
```

Search

O(log n)*

Find node in BST. O(n) worst case for unbalanced.

```
if (!node || node.val === value) return node;
return value < node.val
  ? search(node.left, value)
  : search(node.right, value);
```

DFS Traversal

O(n)

Depth-first: preorder, inorder, postorder.

```
// Inorder (sorted in BST)
inorder(node) {
  inorder(node.left);
  visit(node);
  inorder(node.right);
}
```

BFS Traversal

O(n)

Level by level using queue.

```
const queue = [root];
while (queue.length) {
  const node = queue.shift();
  queue.push(node.left, node.right);
}
```

Delete

O(log n)*

Remove node and maintain BST property.

```
// Find min in right subtree
// Replace node with min
// Delete min from right
```

Height/Depth

O(n)

Find max depth of tree.

```
return !node ? 0 : 1 + Math.max(
  height(node.left),
  height(node.right)
);
```

Graphs

Common Operations

Add Vertex

O(1)

Add new vertex to adjacency list.

```
graph[vertex] = [];
```

Add Edge

O(1)

Connect two vertices (nodes).

```
graph[v1].push(v2);
// For undirected:
graph[v2].push(v1);
```

BFS

O(V + E)

Breadth-first traversal using queue.

```
const q = [start];
while (q.length) {
  const v = q.shift();
  q.push(...graph[v]);
}
```

DFS

O(V + E)

Depth-first traversal using recursion/stack.

```
function dfs(vertex) {
  visited.add(vertex);
  graph[vertex].forEach(v => {
    if (!visited.has(v)) dfs(v);
  });
}
```

Find Path

O(V + E)

Find path between two vertices.

```
// Using BFS/DFS
while (queue.length) {
  const v = queue.shift();
  if (v === target) return path;
}
```

Check Cycle

O(V + E)

Detect cycle in directed/undirected graph.

```
function hasCycle(v, parent) {
  if (visited.has(v)) return true;
  return graph[v].some(next =>
    next !== parent && hasCycle(next, v)
  );
}
```

Sorting

Common Algorithms

Bubble Sort

$O(n^2)$

Compare adjacent elements and swap if needed. Simple but inefficient.

```
for (let i = 0; i < n; i++) {
  for (let j = 0; j < n - i - 1; j++) {
    if (arr[j] > arr[j + 1]) {
      [arr[j], arr[j + 1]] = [arr[j + 1], arr[j]];
    }
  }
}
```

Quick Sort

$O(n \log n)$*

Pick pivot, partition array, recursively sort. $O(n^2)$ worst case.

```
function quickSort(arr, low, high) {
  if (low < high) {
    let pi = partition(arr, low, high);
    quickSort(arr, low, pi - 1);
    quickSort(arr, pi + 1, high);
  }
}
```

Merge Sort

$O(n \log n)$

Divide array, sort halves, merge results. Stable sort.

```
function mergeSort(arr) {
  if (arr.length <= 1) return arr;
  let mid = Math.floor(arr.length / 2);
  return merge(
    mergeSort(arr.slice(0, mid)),
    mergeSort(arr.slice(mid))
  );
}
```

Insertion Sort

$O(n^2)$

Build sorted array one item at a time. Good for small n.

```
for (let i = 1; i < n; i++) {
  let key = arr[i];
  let j = i - 1;
  while (j >= 0 && arr[j] > key) {
    arr[j + 1] = arr[j];
    j--;
  }
  arr[j + 1] = key;
}
```

Heap Sort

$O(n \log n)$

Build max heap, repeatedly extract max. In-place sort.

```
function heapSort(arr) {
  buildMaxHeap(arr);
  for (let i = arr.length - 1; i > 0; i--) {
    [arr[0], arr[i]] = [arr[i], arr[0]];
    heapify(arr, 0, i);
  }
}
```

Selection Sort

$O(n^2)$

Find min element, place at start. Simple but inefficient.

```
for (let i = 0; i < n - 1; i++) {
  let min = i;
  for (let j = i + 1; j < n; j++) {
    if (arr[j] < arr[min]) min = j;
  }
  if (min !== i) [arr[i], arr[min]] = [arr[min], arr[i]];
}
```

Search

Common Algorithms

Linear Search

O(n)

Check each element sequentially. Works on unsorted arrays.

```
function linearSearch(arr, target) {
  for (let i = 0; i < arr.length; i++) {
    if (arr[i] === target) return i;
  }
  return -1;
}
```

Binary Search

O(log n)

Divide and conquer. Requires sorted array.

```
function binarySearch(arr, target) {
  let left = 0, right = arr.length - 1;
  while (left <= right) {
    let mid = Math.floor((left + right) / 2);
    if (arr[mid] === target) return mid;
    if (arr[mid] < target) left = mid + 1;
    else right = mid - 1;
  }
  return -1;
}
```

Jump Search

O(√n)

Jump fixed steps, then linear search. For sorted arrays.

```
function jumpSearch(arr, target) {
  const step = Math.floor(Math.sqrt(arr.length));
  let prev = 0;
  while (arr[Math.min(step, arr.length) - 1] < target) {
    prev = step;
    step += Math.floor(Math.sqrt(arr.length));
    if (prev >= arr.length) return -1;
  }
  // Linear search in block
  while (arr[prev] < target) {
    prev++;
    if (prev === Math.min(step, arr.length)) return -1;
  }
  return arr[prev] === target ? prev : -1;
}
```

Interpolation Search

O(log log n)*

Like binary search but with better position guessing.

```
function interpolationSearch(arr, target) {
  let low = 0, high = arr.length - 1;
  while (low <= high && target >= arr[low]
         && target <= arr[high]) {
    let pos = low + Math.floor(
      (target - arr[low]) * (high - low) /
      (arr[high] - arr[low])
    );
    if (arr[pos] === target) return pos;
    if (arr[pos] < target) low = pos + 1;
    else high = pos - 1;
  }
  return -1;
}
```

Thank You!

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