ALGORITHMS AND DATA STRUCTURES

CHEAT SHEET

DATA STRUCTURE

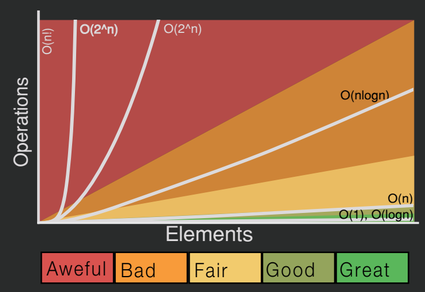
Data Structure	Time Complexity								Space Complexity
	Average				Worst				Worst
	Access	Search	Insertion	Deletion	Access	Search	Insertion	Deletion	
Array	O(1)	O(n)	O(n)	O(n)	O(1)	O(n)	O(n)	O(n)	O(n)
Stack	O(n)	O(n)	O(1)	O(1)	O(n)	O(n)	O(1)	O(1)	O(n)
Queue	O(n)	O(n)	O(1)	O(1)	O(n)	O(n)	O(1)	O(1)	O(n)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

GRAPH OPERATION

Representation	Time Complexity					Space Complexity
	Add Node	Add Edge	Remove Node	Remove Edge	Query	
Adjacency List	O(1)	O(1)	O(V+E)	O(E)	O(E)	O(V+E)
Adjacency Matrix	O(V^2)	O(1)	O(V^2)	O(1)	O(1)	O(V^2)
Incidence List (Edge)	O(1)	O(1)	O(E)	O(E)	O(E)	O(V+E)
Incident Matrix	O(V.E)	O(V.E)	O(V.E)	O(V.E)	O(E)	O(V.E)

HEAP OPERATION

Type	Time Complexity						
	Heapify	Find Min	Pop Min	Add	Remove	Merge	Decrease Key
Linked List (sorted)	N/A	O(1)	O(1)	O(n)	O(1)	O(m+n)	O(n)
Linked List	N/A	O(n)	O(n)	O(1)	O(1)	O(1)	O(1)
Binary Heap	O(n)	O(1)	O(log(n))	O(log(n))	O(log(n))	O(m+n)	O(log(n))
Binomial Heap	N/A	O(1)	O(log(n))	O(1)	O(log(n))	O(log(n))	O(log(n))
Fibonacci Heap	N/A	O(1)	O(log(n))	O(1)	O(log(n))	O(1)	O(1)



SORTING ALGORITHMS

Algorithm	Time Complexity			Space Complexity
	Best	Average	Worst	Worst
Quicksort	Ω(nlog(n))	θ(nlog(n))	O(n^2)	O(nlog(n))
Mergesort	Ω(nlog(n))	θ(nlog(n))	O(nlog(n))	O(nlog(n))
Timsort	Ω(n)	θ(nlog(n))	O(nlog(n))	θ(n)
Heapsort	Ω(nlog(n))	θ(nlog(n))	O(nlog(n))	O(nlog(n))
Bubble sort	Ω(n)	θ(n^2)	O(n^2)	θ(n)
Insertion sort	Ω(n)	θ(n^2)	O(n^2)	θ(n)
Selection sort	Ω(n^2)	θ(n^2)	O(n^2)	Ω(n^2)
Shell sort	Ω(nlog(n))	θ(n(log(n))^2)	O(n(log(n))^2)	O(nlog(n))
Bucket sort	Ω(n+k)	θ(n+k)	O(n^2)	Ω(n+k)
Radix sort	Ω(n+k)	θ(n+k)	Ω(n+k)	Ω(n+k)
Counting sort	Ω(n+k)	θ(n+k)	Ω(n+k)	Ω(n+k)
Cube sort	Ω(n)	θ(nlog(n))	O(nlog(n))	O(nlog(n))
Tree sort	Ω(nlog(n))	θ(nlog(n))	O(n^2)	O(nlog(n))

GRAPH ALGORITHMS

Algorithm	Time Complexity		Space Complexity
	Average	Worst	Worst
Breadth First Search	O(V+E)	O(V+E)	O(V)
Depth First Search	O(V+E)	O(V+E)	O(V)
Shortest Path (Grid)	O(nxm)	O(nxm)	O(nxm)
Shortest Path (DAG)	O(V+E)	O(V+E)	O(V)
Dijkstra	O((E+V)log(V))	O(V^2)	O(V+E)
A* (A-Star) Heuristic	N/A	O(E)=O(b^d)	O(V)=O(b^d)
Bellman-Ford (SSSP)	O(V.E)	O(V.E)	O(V)
Topological Sort (Kahn's)	O(V+E)	O(V+E)	O(V)
MST (Kruskal's)	O(Elog(E))	O(Elog(V))	O(E)
MST (Prim's)	O(Elog(V))	O(V^2)	O(V)
Floyd-Warshall (Shortest Path)	O(V^3)	O(V^3)	O(V^2)
Connected Component	O(V+E)	O(V+E)	O(V)
Tarjan's	O(V+E)	O(V+E)	O(V)
Articulation Points/ Bridges	O(V+E)	O(V+E)	O(V)
Bipartite Graph	NP-Complete	NP-Complete	NP-Complete
Find Cycle (Directed Graph)	O(V+E)	O(V+E)	O(V)
Find Cycle (Undirected Graph)	O(V+E)	O(V+E)	O(V)