

“ALGO TOOLBOX” TRAINING

1. See the Data - *algo question = numbers and data* - The words and “theme” is a trap... only see data and numbers
2. Multiple Passes - *simplify & modify into more familiar problems*
3. Problem & Data Type Toolbox - *train by practice / memorize*

ADT TOOLBOX

hash-map *dictionary* - $O(1)$ to look up data based on key, $O(1)$ to set data based on key. **Your fave ADT for faster, simpler algos!**

list *array, sequence* - $O(n)$ to linear search, $O(1)$ to look up index - good for ordered data

stack *Last in First Out* - $O(1)$ to add or remove - good for reversing things, recursive things

queue *First in First Out* - $O(1)$ to add or remove - good for processing things in order

tree *root* node connected to children and descendants

graph *vertices* connected with *edges*

SORTING ALGOS

quicksort *time avg* $O(n \log n)$ - *space* $O(\log n)$ - pick a pivot, sort w.r.t. to pivot into two partitions, sort each partition using quicksort (another pivot)

mergesort *time avg* $O(n \log n)$ - *space* $O(n)$ - split, sort each array using mergesort (smaller arrays), combine sorted arrays in order

insertion sort *time avg* $O(n^2)$ - *space* $O(1)$ - “pick up” an item, and move left into sorted portion until you find a spot where it fits between, then place

selection sort *time avg* $O(n^2)$ - *space* $O(1)$ - find smallest item, put on left in sorted portion, then repeat for next smallest in unsorted

bubblesort *time avg* $O(n^2)$ - *space* $O(1)$ - keep on swapping adjacent items, until you go through the array with no more items needing to be swapped

PROBLEM TOOLBOX

minimum $O(n)$

```
min_found = None
for n in list_of_numbers:
    if min_found == None:
        min_found = n
    if n < min_found:
        min_found = n
```

maximum $O(n)$ - implementation is same as above, save for $n > \text{max_found}$

counting occurrences $O(n)$

```
c = {}
for item in items:
    if item not in c:
        c[item] = 0
    c[item] += 1
```

filtering collection $O(n)$ - create a new, smaller list only containing data adhering to a condition

```
output = []
for item in items:
    if item > 5: # or something
        output.append(item)
```

transforming collection $O(n)$ - create a list of same length, but with data changed

```
output = []
for item in items:
    # Any method or operation
    modified = item * 2
    output.append(modified)
```

intersection between collections $O(n)$ - find items in one collection that are (or are not) in another collection. Use **set** instead of **list** since set operations are $O(1)$

```
data_2_set = set(data_2)
overlap = []
for item in data_1:
    if item in data_2_set:
        overlap.append(item)
```

cross operation $O(n^2)$ - perform operation on each element w.r.t. another element

```
out = []
for a in data_1:
    for b in data_2:
        out.append(a * b)
```

DATA STRUCTURES

Many approaches to implement ADTs:

Linked lists Implement with dicts

```
c = {"data": "C", "next": None}
b = {"data": "B", "next": c}
a = {"data": "A", "next": b}
```

Stacks, queues Just a list, but only using first and/or last items

Tree Impl. with dicts and lists

```
root = {
    "data": "Grandma",
    "children": [{
        "data": "Mom",
        "children": [{"data": "Me"}],
    }, {
        "data": "uncle",
        "children": []
    }]
}
```

Graph (directed) Store vertices in dict, outward edges in list

```
graph = {
    "NYC": ["SFO", "ORD", "DTW", "LAX"],
    "SFO": ["LAX", "OAK", "NYC", "DTW"],
    "SAC": ["OAK", "SFO", "LAX"],
}
```

TERMINOLOGY

Poyla's 4 Steps **1** Understand the problem **2** Devise a plan **3** Carry it out **4** Verify & review

Algorithm A precise series of steps that solves a problem

Implementation The code used to perform an algorithm

Time complexity *speed* - “Given a problem input of size n , how many steps does algo take to solve?”

Big O Notation for time complexity

Abstract Data Types Ways to structure data, defined in English, useful to model data

Data structures Implementations with code of an ADT, used to implement algorithms