122com Data structures and types

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Overview

Arrays

C

A series of objects all of the same size and type.

```
char array[] = {'A', 'B', 'C', 'D', 'E'};
```

- Stored in contiguous blocks of memory.
- Python lists are functionally closest.
  - But are not arrays.
- Can't be resized.

Linked lists

C

The challenger for array's crown.

- Series of nodes, each of which points to the next element.
  - And to the previous element if it's a doubly linked list.

Singularly linked $\boxed{A} \rightarrow \boxed{B} \rightarrow \boxed{C} \rightarrow \boxed{D} \rightarrow$

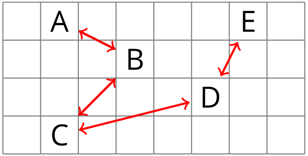
Doubly linked $\leftarrow \boxed{A} \rightleftarrows \boxed{B} \rightleftarrows \boxed{C} \rightleftarrows \boxed{D} \rightarrow$

Linked lists II

A

Not in contiguous memory.

- Each node is separate.
- Scattered.
- Dynamic memory (pointers!).



- Why would we use linked lists instead of arrays?
  - Can change size.
  - Can quickly insert and delete elements.

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class Node:
    __prev = None
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```cpp
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    Node *prev;
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public:
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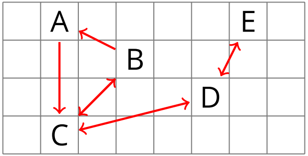

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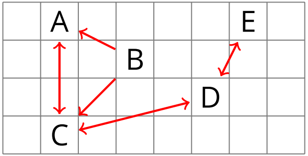

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Removing array elements

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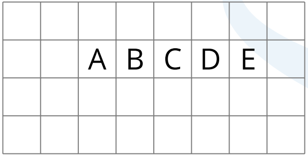

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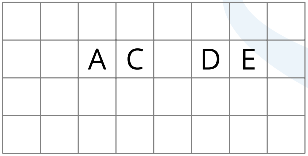

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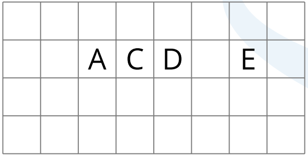

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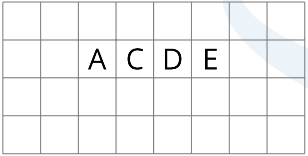

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- Array in memory, multiple elements in a contiguous block.
- How do we remove elements from the middle?
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  3. Repeat.
- Is very slow with large arrays.

Removing linked list elements

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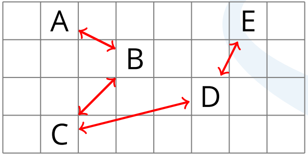

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Removing linked list elements

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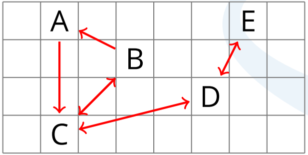

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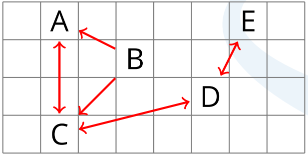

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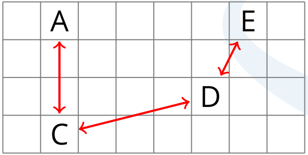

- Linked list, separate elements scattered in memory.
- Each pointing to the next/prev element.
- How do we remove elements?
  1. Change pointers.
  2. Delete old element.

Linked lists III

I

Advantages

- Inserting and deleting elements is very fast.
  - $O(1)$.
- No size limits, can keep adding new elements.
- Doesn't waste memory.

Disadvantages

- Not indexed.
  - Can't ask for the 20th element etc.
  - Have to step through the list (slow).
- Needs more memory than an array to store the same number of elements.
  - Have to keep track of where the next/prev nodes are.

Data structures

C

Arrays and linked lists are data structures.

- A specific way of storing data.
- Can see how the various elements of the structure are laid out in memory.
- Direct access to the underlying memory.

Abstract data types

I

As we move to storing more complex information in our software we well start to encounter Abstract Data Types (ADTs).

- Software engineering principal.

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- Unlike data structure ADTs only concerned with the interface.
- Internals of ADTs can vary widely between implementations.

ADT

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Imagine an ADT like a car.

- It has a set of supported operations, go faster, go slower, turn left, turn right.

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ADT

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- Don’t care how it achieves these.
- Don’t care if, internally, it’s using a combustion engine or an electric motor.

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ADT

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Imagine an ADT like a car.

- It has a set of supported operations, go faster, go slower, turn left, turn right.
- Don't care how it achieves these.
- Don't care if, internally, it's using a combustion engine or an electric motor.
- Only care about the result.

Queues

C

A First In First Out (FIFO) ADT.

- Ends of the queue called the front and back.
- New elements added to back of queue only.
  - Pushing - push(value)
- Old elements removed from front of queue only.
  - Popping - pop()
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  - Linked list.

Array as a queue.

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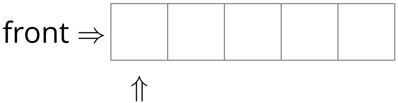

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  - Keep track of next free space.
  - Limited size.

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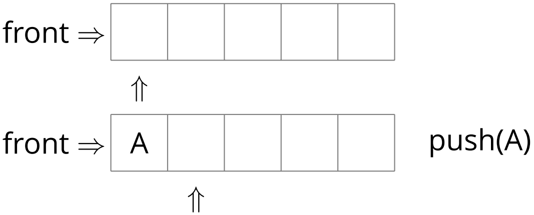

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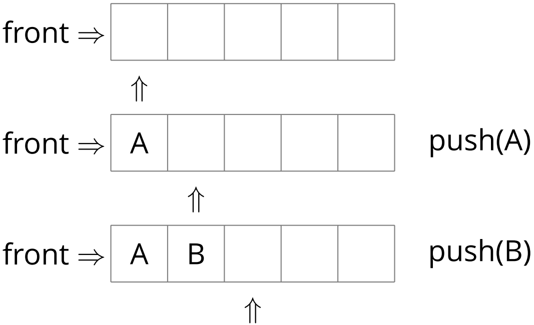

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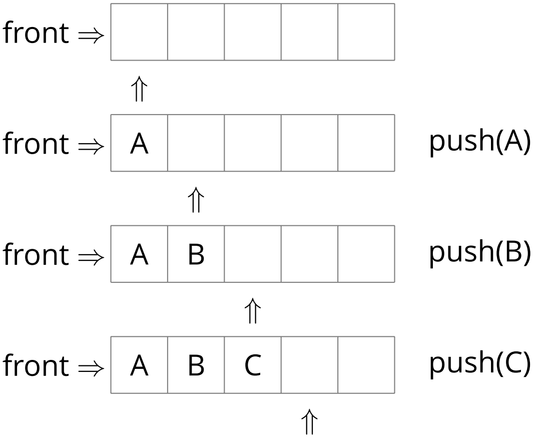

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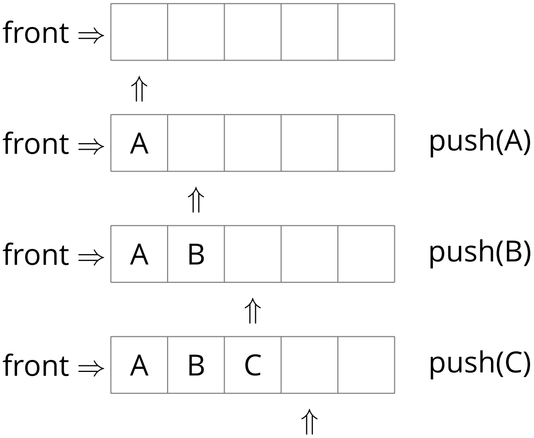

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  - Inefficient.

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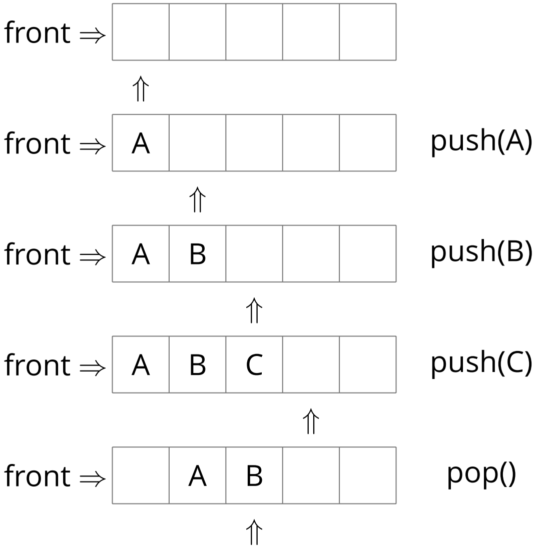

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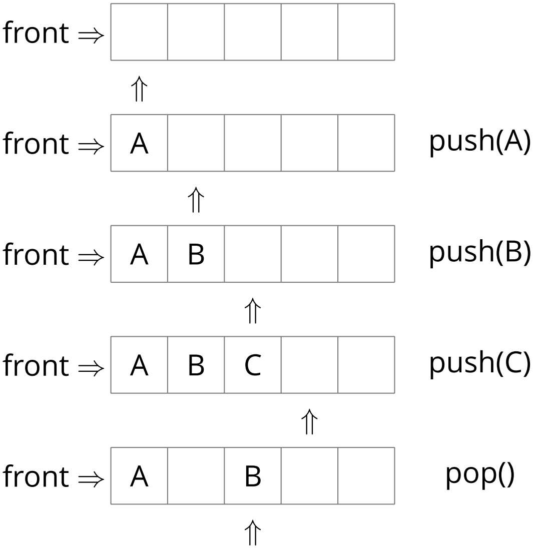

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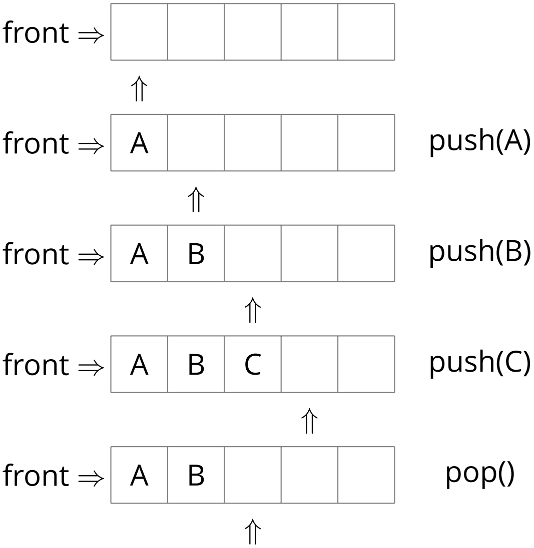

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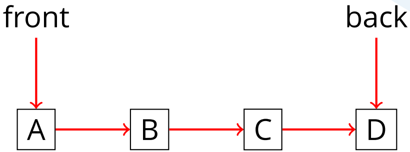

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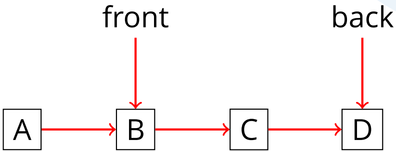

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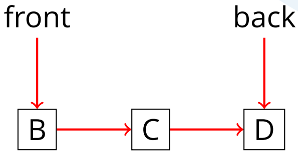

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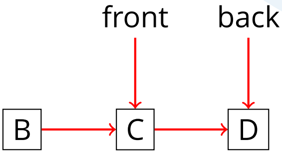

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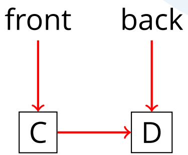

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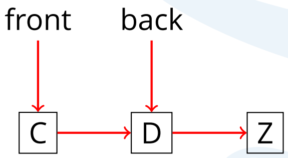

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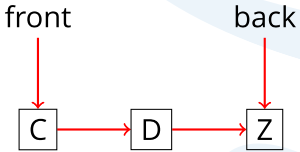

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- Which would be better for a stack? An array or a linked list?
  - Doesn’t matter performance wise.
  - Linked list if *n* is unknown.

Array as a stack.

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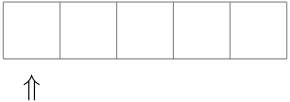

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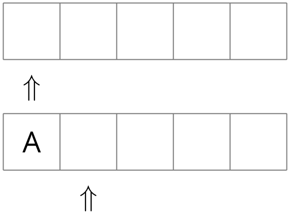

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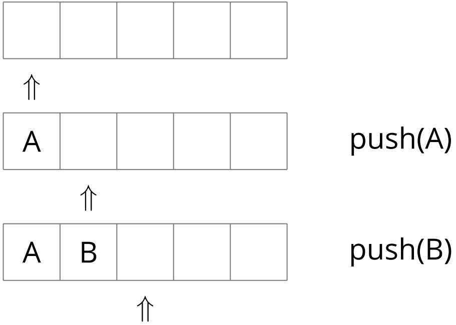

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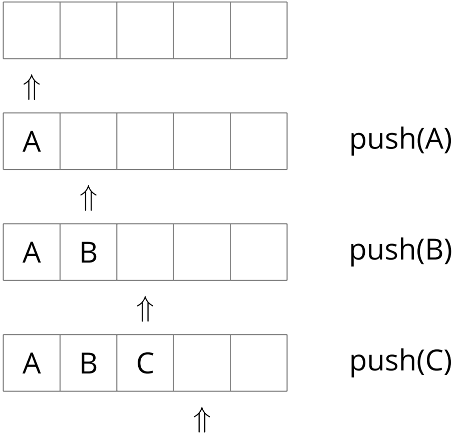

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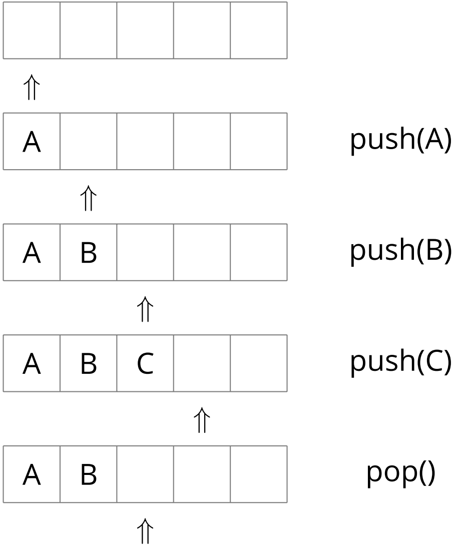

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Sets

C

- An unordered ADT.
    - Items ordered by the set.
    - You have no control over it.
- Sets contain unique elements.
    - Can't contain duplicates.

- Can add items to a set.
- Can remove items from a set.
- Can see if an item is in a set.
- Can't get the n^{th} element.
    - It's unordered remember.

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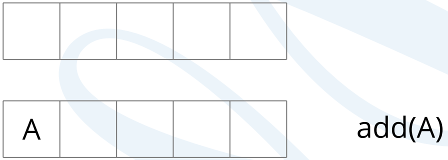

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A	B				add(B)

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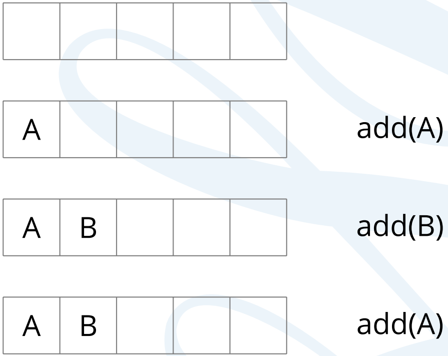

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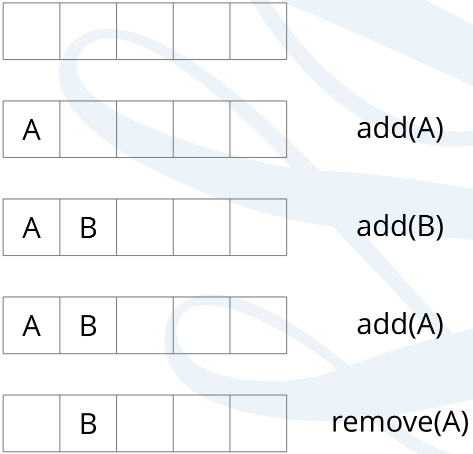


...and the others

C

- Lots of other ADTs.
- Different names in different languages.

- Lists.
- Circular lists.
- Associative arrays.
  - Dictionaries/Maps.
- Double-ended queues.
- Trees.
- Graphs.

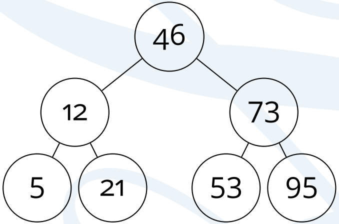
Trees

A

Variation on linked lists.

- Made of nodes and relationships.
- Root node at top.
- Each node can have ≥ 0 children.

- Binary search tree.
  - Very common type.
  - Ordered.
  - Max two children.
  - Binary searching.
  - Very good for sets.

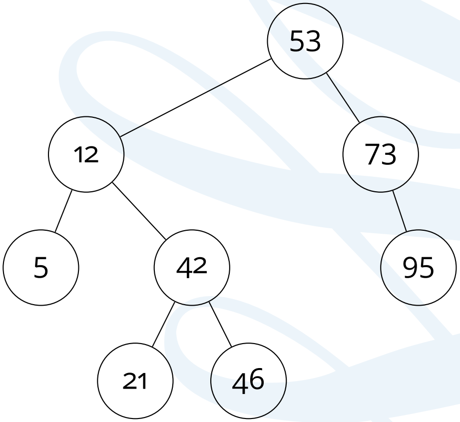


Balance

A

- Trees can be balanced or unbalanced.
- Not required for all trees.
- Going to be talking about BSTs from here on.

- Unbalanced because more than a one node difference between the two halves.

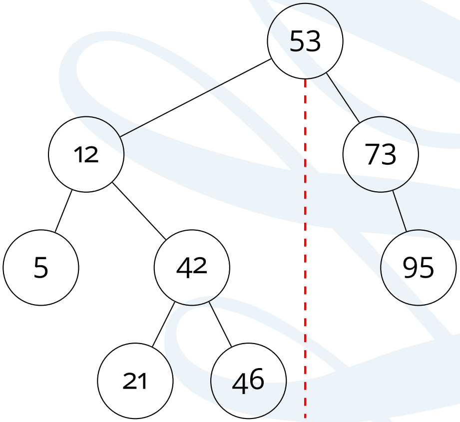


Balance

A

- Trees can be balanced or unbalanced.
- Not required for all trees.
- Going to be talking about BSTs from here on.

- Unbalanced because more than a one node difference between the two halves.
  - For the whole tree...

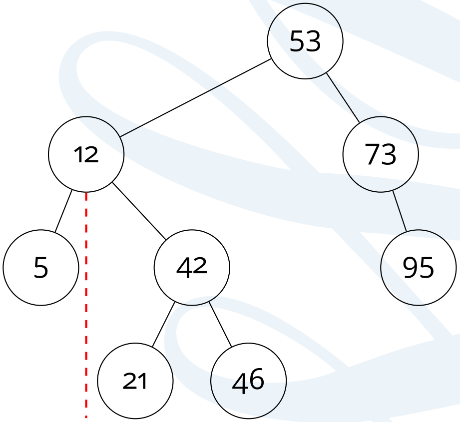


Balance

A

- Trees can be balanced or unbalanced.
- Not required for all trees.
- Going to be talking about BSTs from here on.

- Unbalanced because more than a one node difference between the two halves.
  - For the whole tree...
  - ...and one of the subtrees.



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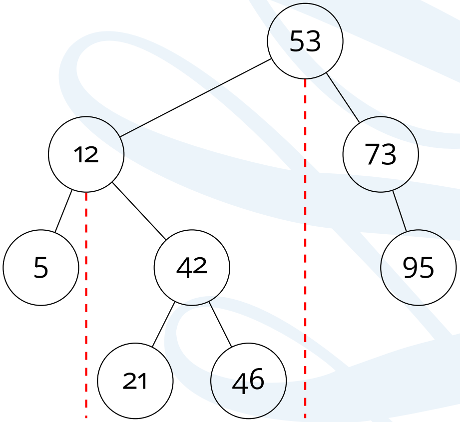
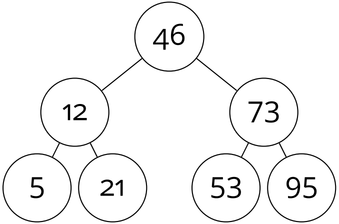


Balance

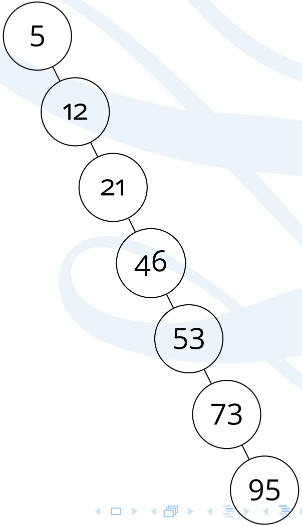
A

Important that you keep your BSTs balanced.

Perfect tree.



Degenerate tree.



Quiz

Recap

- Arrays.
  - Advantages/disadvantages.
- Linked lists .
  - Advantages/disadvantages.
  - How to insert/delete.
- Difference between data structure and ADTs.
- Stack.
  - FILO.
  - Using an array as one.
  - Using a LL as one.
- Queue.
  - FIFO.
  - Using an array as one.
  - Using a LL as one.
- Sets.
  - No duplicates.
  - Unordered.
- Trees.
  - Balanced/unbalanced.

The End