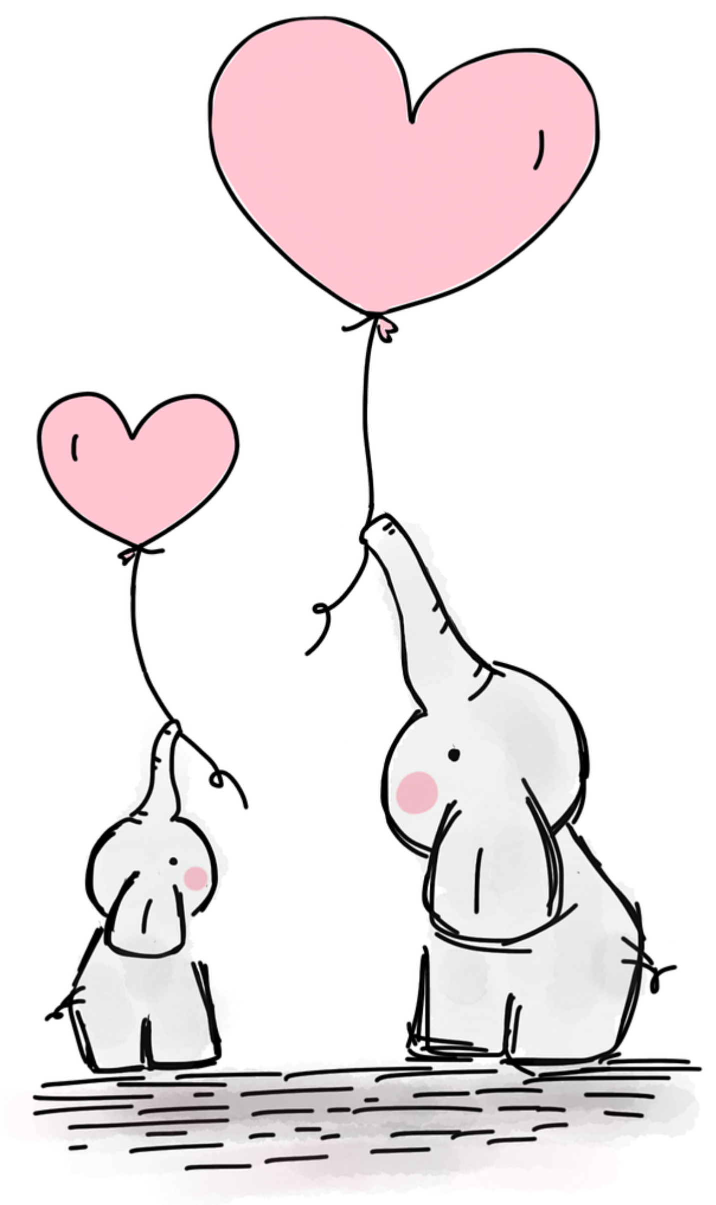
Efficient Phrases

These are efficient phrases:	These are not efficient phrases:
Cold Windowsill	Chilly Window Ledge
Cool Million	Good Thousand Thousand
Vivid Disillusions	Graphic Disappointments
Suspicious Conclusion	Mistrustful Ending

What makes an efficient phrase?

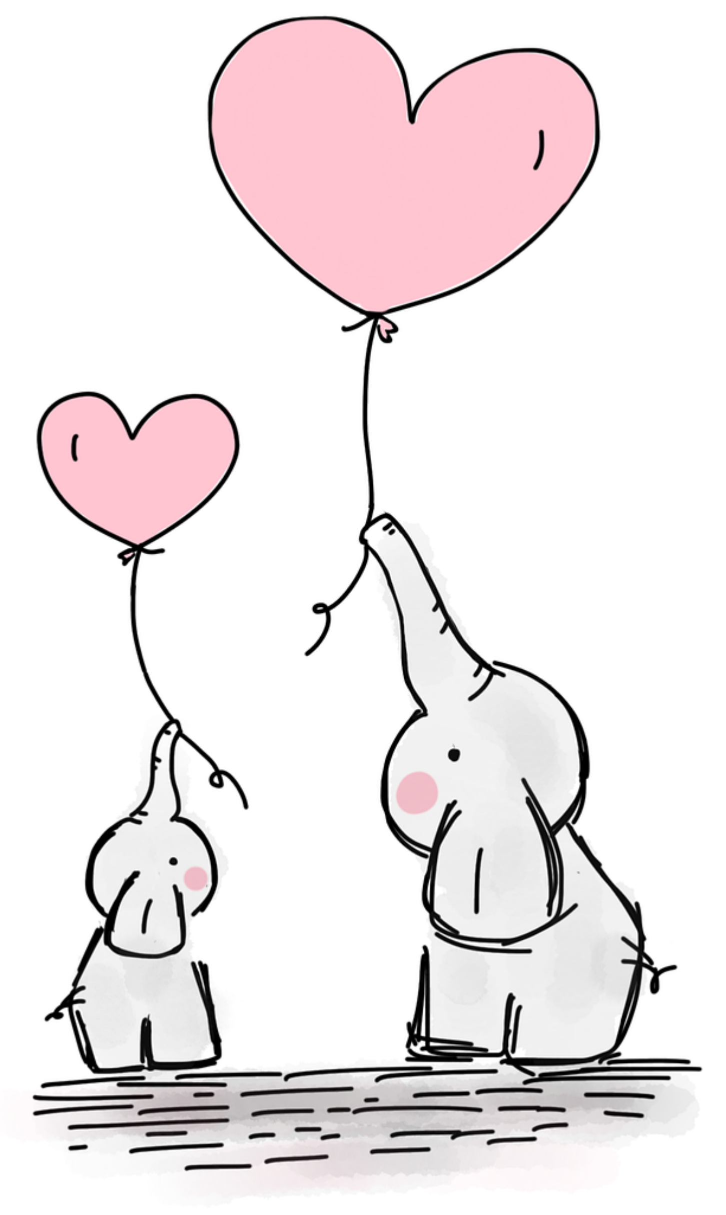
Data Structures

Data Structures



Data Structures

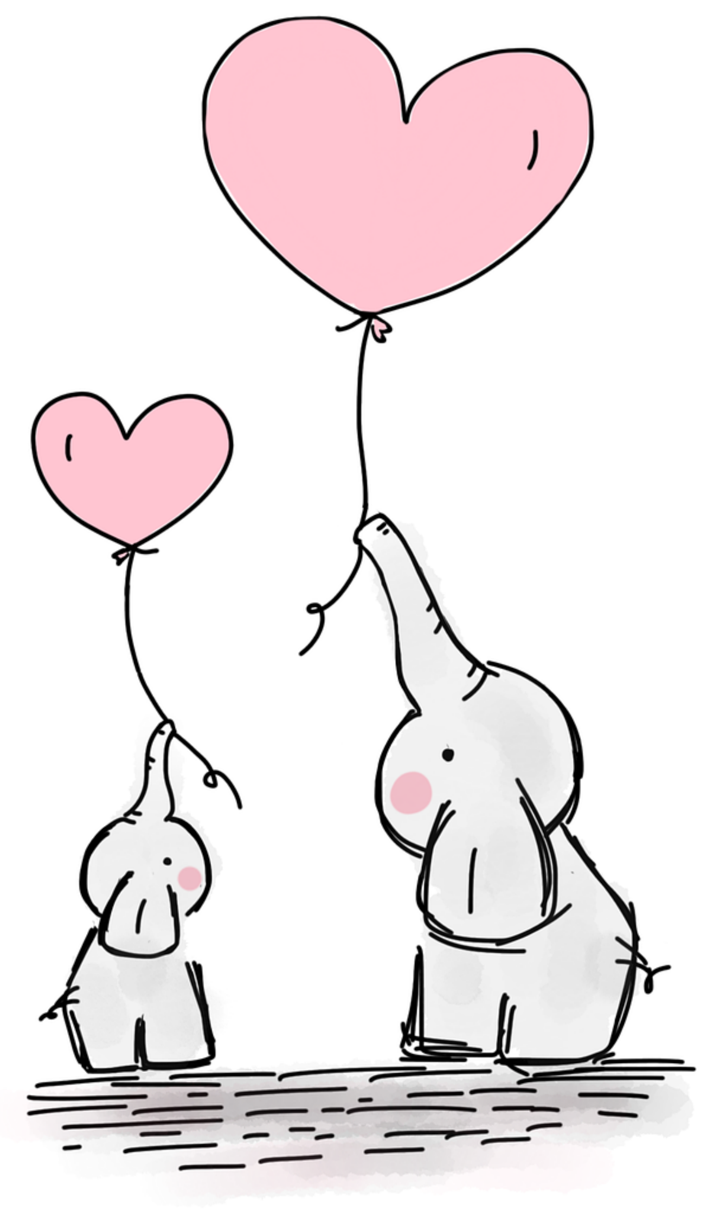
Data Structures



Data Structures

Data Structures

- Sequence Types
  - Tuples
  - Lists
  - `range`



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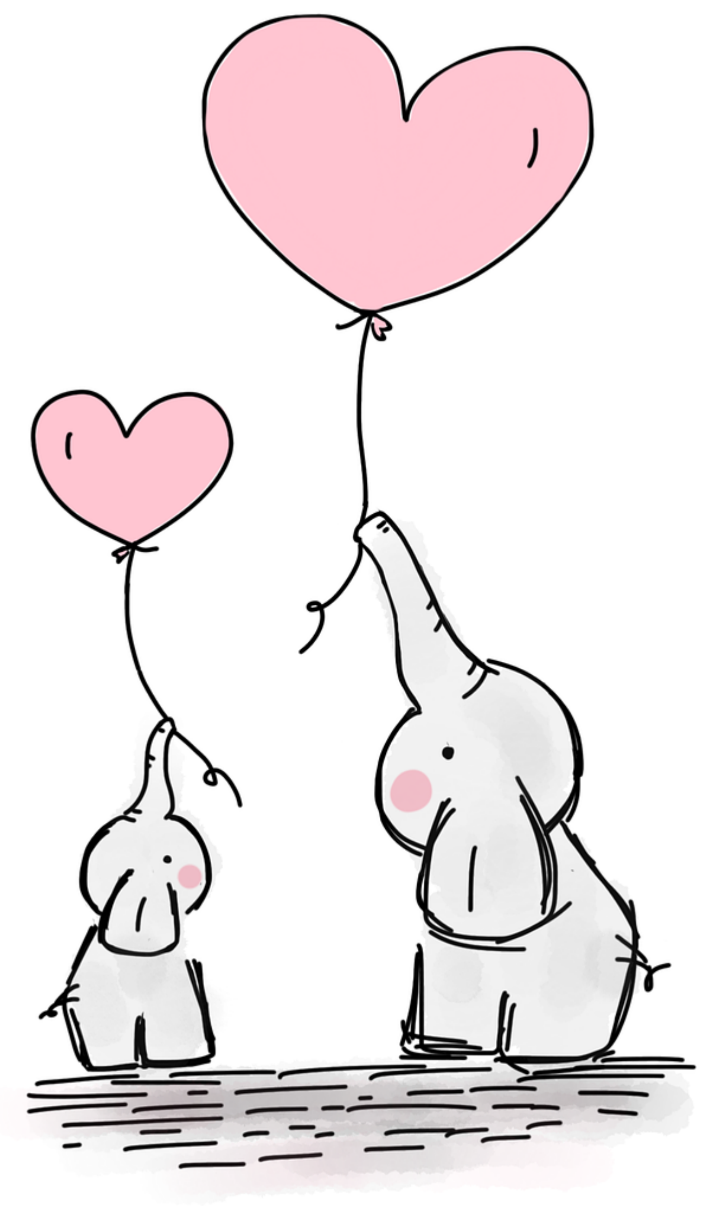

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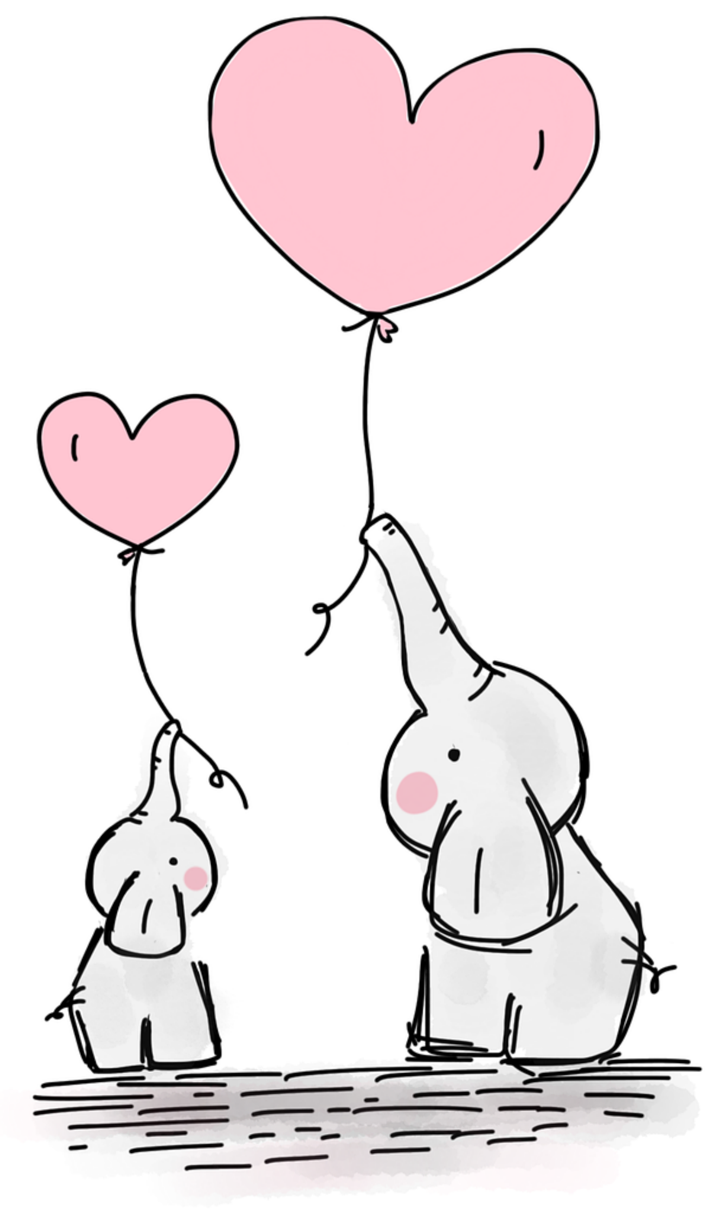

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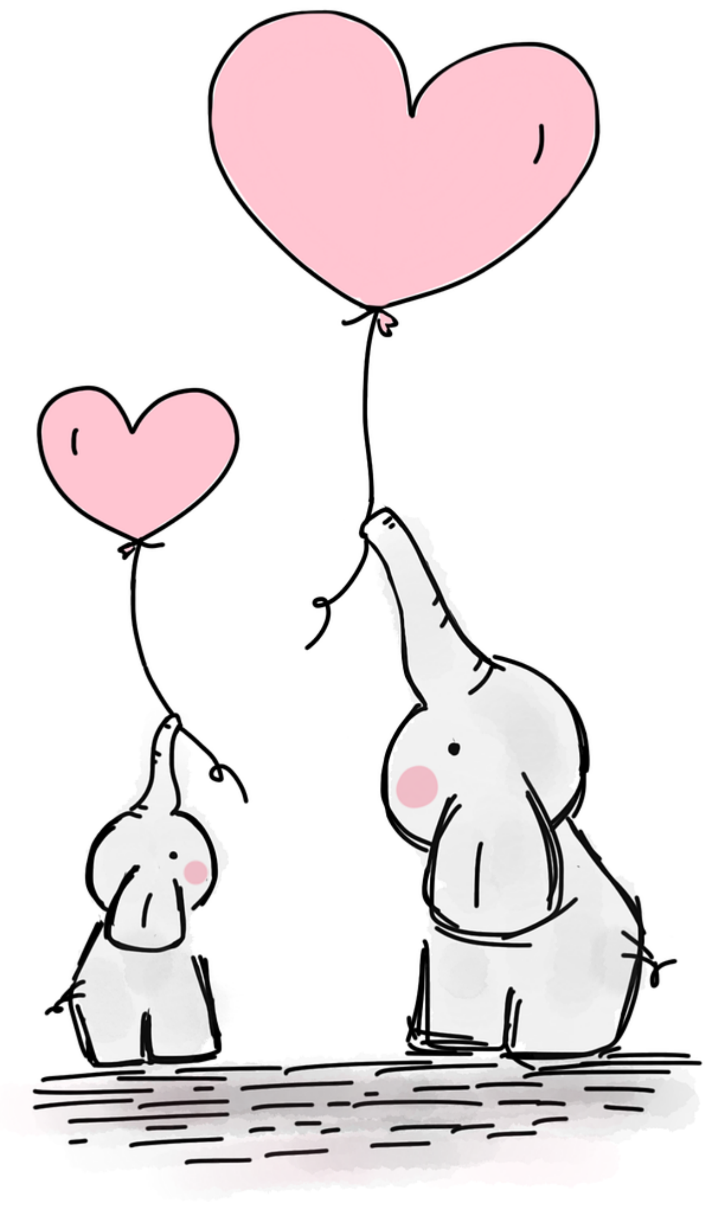

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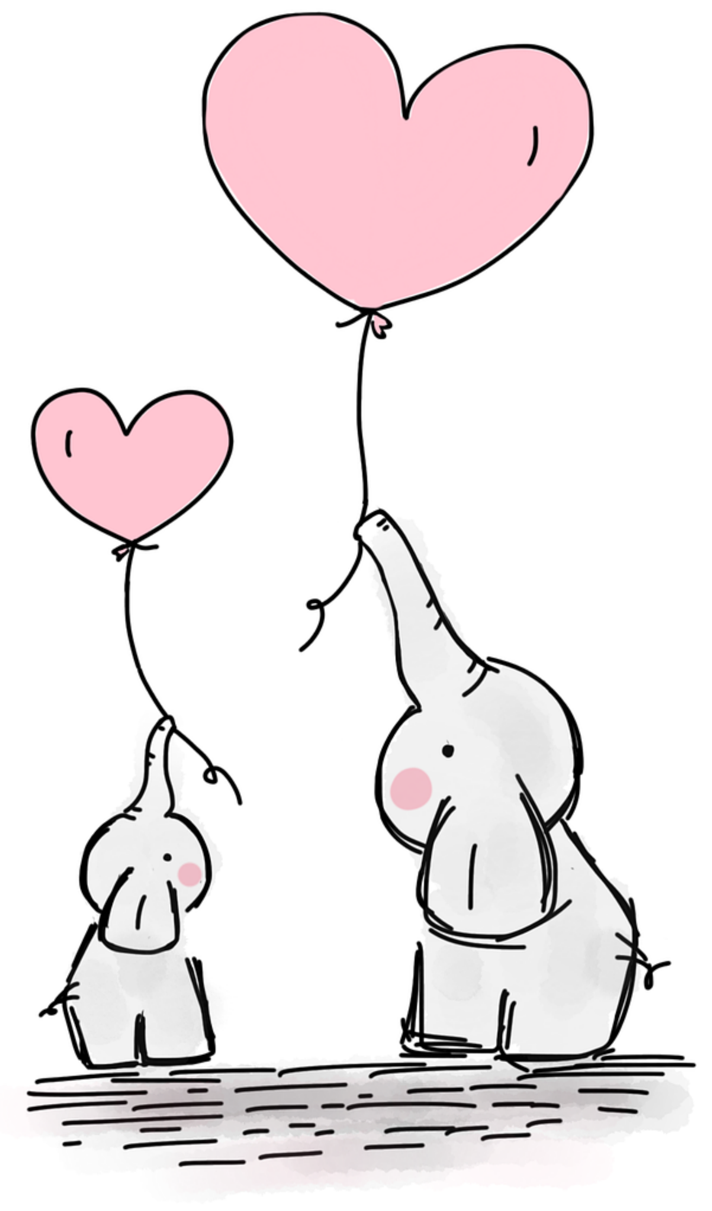

Sequence Types

Sequence type: an object type for storing an ordered collection of objects.

Sequence type: an object type for storing an <u>ordered</u> collection of objects.

Today, we'll be exploring `tuple` objects, `list` objects, and `range` objects!

Tuples

Tuple: immutable sequence type, typically used to store a collection of heterogeneous data.

Cannot be changed after it's been created.

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Cannot be changed after it's been created.

Tuple: immutable sequence type, typically used to store a collection of heterogeneous data.

Can store objects of various type.

```
congrats = ("Happy", 4, "you", "dude!")
congrats =  "Happy", 4, "you", "dude!"
```

$\underbrace{\phantom{\text{"Happy", 4, "you", "dude!"}}}_{\text{Parentheses are conventional, but optional!}}$

Why Learn About Tuples?

Tuples are:

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Tuples are:

- **Hashable** - can be used as keys for dictionaries or as elements of sets. (We'll see more of this soon!)

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Why Learn About Tuples?

Tuples are:

- **Hashable** - can be used as keys for dictionaries or as elements of sets. (We'll see more of this soon!)
- **Immutable** - "write-protect" data that doesn't need to be changed.
- **Memory efficient** - immutability means they are stored more compactly than lists. (Matters more when storing many elements).

Unpacking Tuples

Unpacking Tuples

- Python supports the ready conversion of tuple elements to variables…

```
tup = (3, 2, 1)
three, two, one = tup
```

Unpacking Tuples

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- …and function arguments!

```
pow(*tup)
# => 0
```

Unpacking Tuples

- Python supports the ready conversion of tuple elements to variables…

```
tup = (3, 2, 1)
three, two, one = tup
```

- …and function arguments!

```
pow(*tup)
# => 0
```

$\longleftarrow$ The `*` indicates tuple unpacking; Python interprets this as `pow(3, 2, 1)`

Note: `pow(base, exp, mod)` returns `base**exp % mod`

Aside: Variable Swapping

Using a Temporary Variable:

Using Tuple Packing/Unpacking:

Aside: Variable Swapping

Using a Temporary Variable:

```
tmp = a
a = b
b = tmp
```

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Aside: Variable Swapping

Using a Temporary Variable:

```
tmp = a
a = b
b = tmp
```

Using Tuple Packing/Unpacking:

We create a tuple `(a, b)`…

```
b, a = a, b
```

And unpack its values into `b` and `a`!

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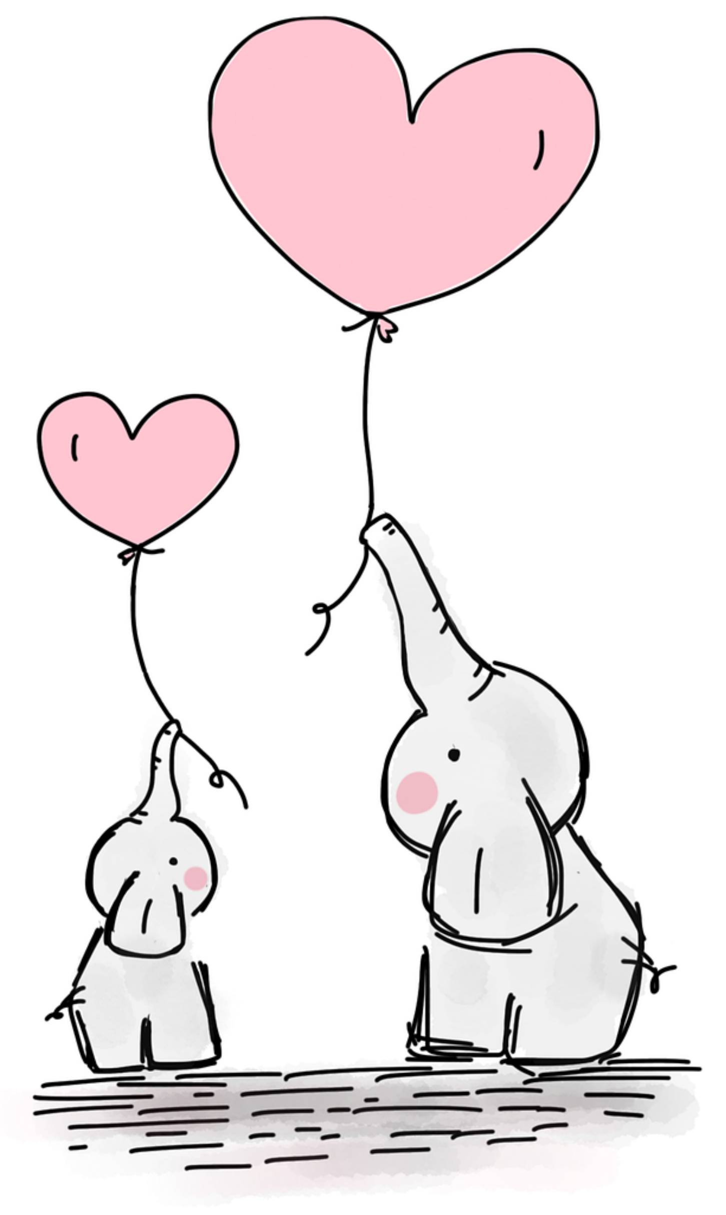

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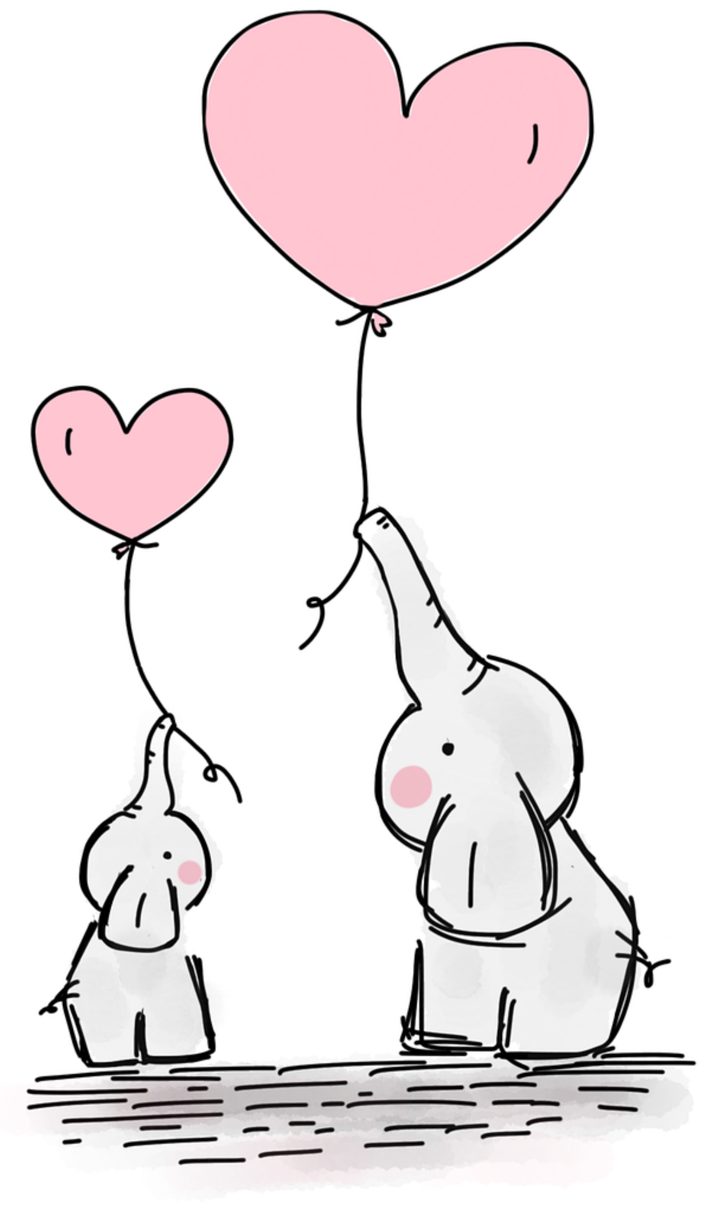

Lists

List: mutable sequence type.

Can be changed after it's been created.

List: mutable sequence type.

```
jenny = [8, 6, 7, 5, 3, 0, 9]
jenny = [8, 6, 7, 5, 3, 0, 9]
```

Unlike with tuples, the brackets are mandatory!

Working with Lists

- Standard slicing rules apply to access elements and subsequences.
- Additionally, special list methods include:

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`.count(elem)`	Counts the occurrences of `elem` in the list.
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`.pop(i=-1)`	Returns and removes the ith element from the list.
`.remove(elem)`	Removes the first instance of `elem` from the list, or raises `ValueError`.

Mutability and Immutability

```
CS41_staff = (["Elizabeth", "Antonio", "Theo"], ["Pop Tart"])

CS41_staff[1].append("Unicornelius")
```

What's going to happen?

Mutability and Immutability

```
CS41_staff = (["Elizabeth", "Antonio", "Theo"], ["Pop Tart"])

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What's going to happen?

Tuples store references to underlying objects; if the objects are mutable, they can still be changed.

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What's going to happen?

Tuples store references to underlying objects; if the objects are mutable, they can still be changed.

```
CS41_staff = (["Elizabeth", "Antonio", "Theo"],
              ["Pop Tart", "Unicornelius"])
```

(If these objects aren't hashable, though, the tuple won't be either!)

An interview question: write a program to remove duplicate elements of a list.

An interview question: write a program to remove duplicate elements of a list.

Fun fact: freshman-year Michael failed to solve this problem
in a real technical interview! 🙃

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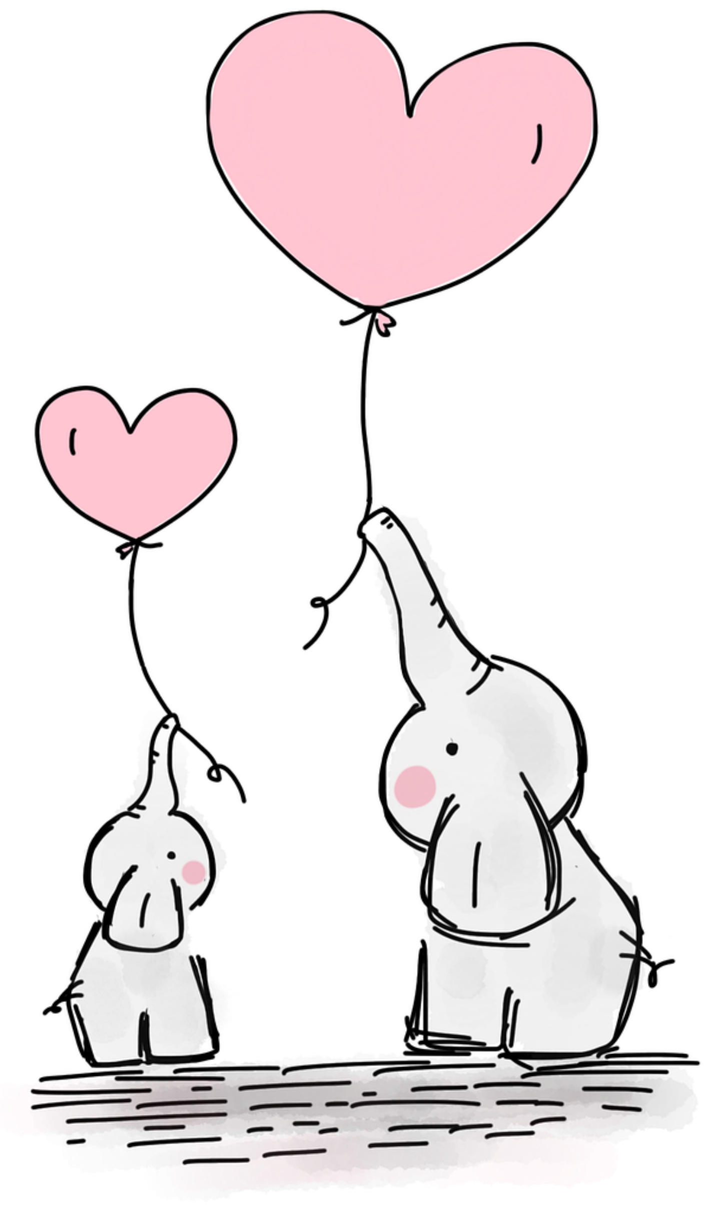

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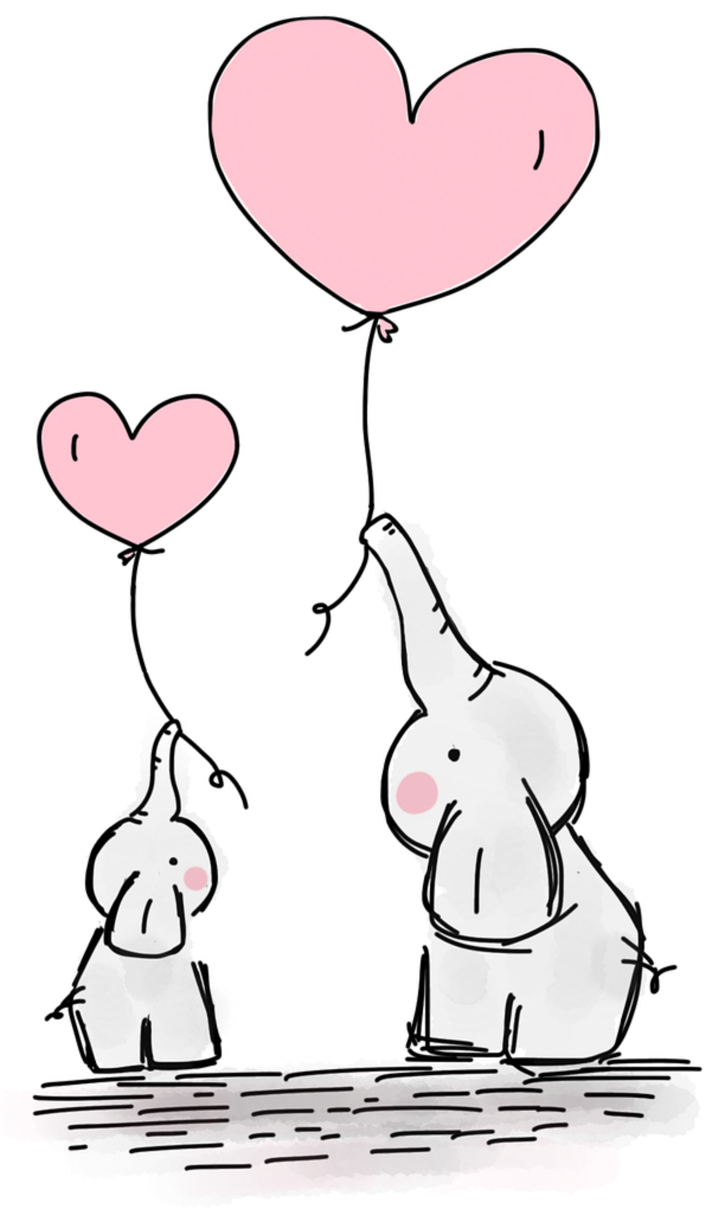

`range`

Range: represents an immutable sequence of numbers, commonly used for looping in `for` loops.

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range(start, stop, step)
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Assumed to be 0 if excluded.

```
range(start, stop, step)
```

Assumed to be 1 if excluded.

```
range(10)
range(10)
```

```
range(3, 10)
range(10)

range(3, 10)

range(3, 10, 2)
```

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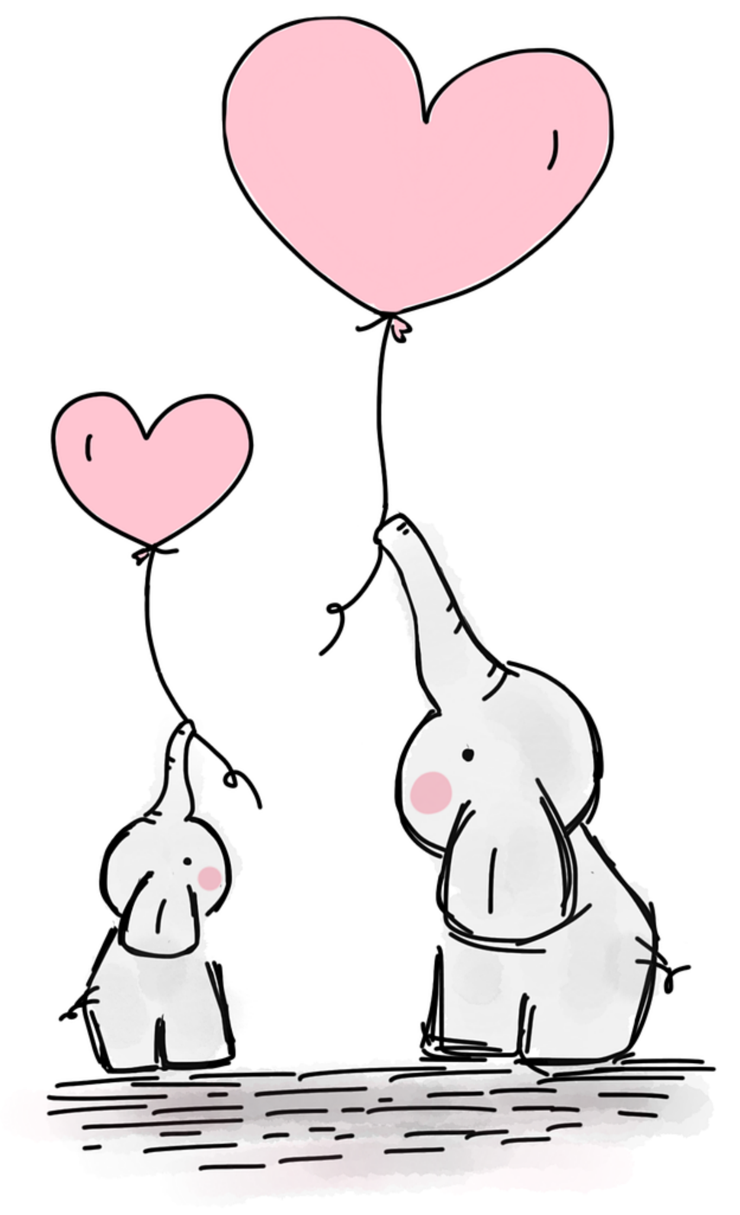

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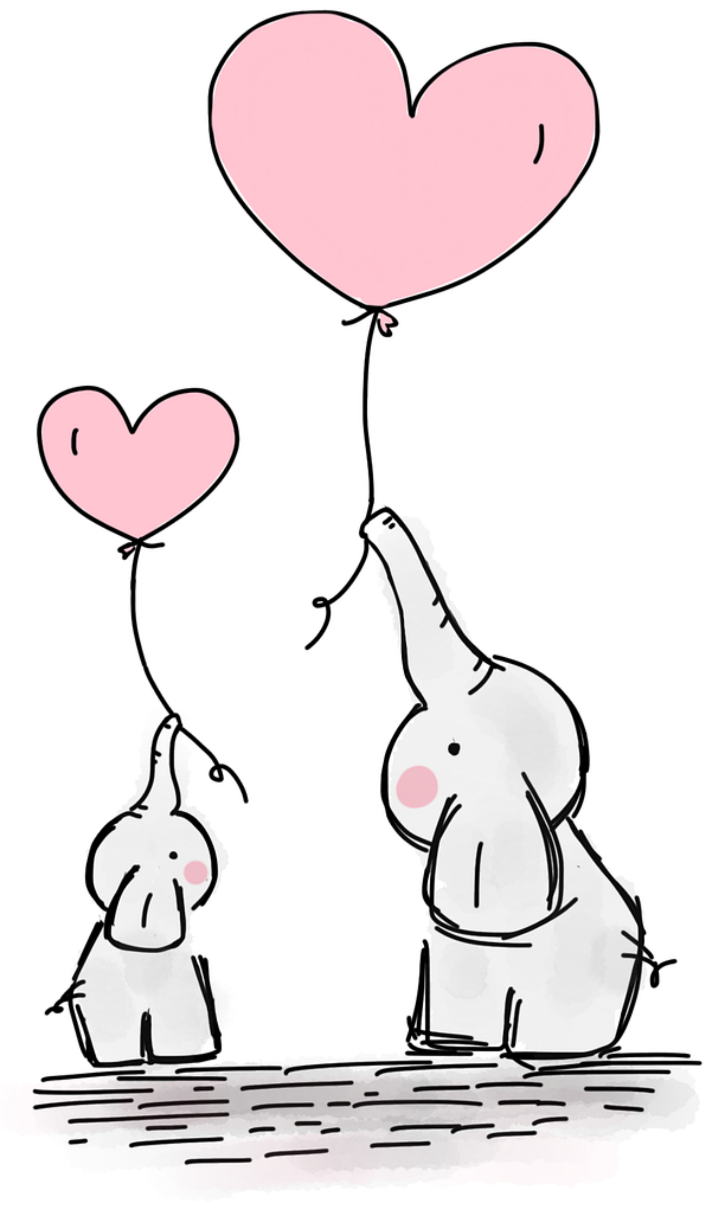

Mapping Types

Dictionaries

Dictionary: a data structure which maps hashable values to arbitrary objects.

For today, hashable and immutable mean the same thing - but we'll revisit this definition during the lecture on Object Oriented Python!

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Dictionary: a data structure which maps hashable values to arbitrary objects.

Think Java's `HashMap`, or the Stanford C++ Library's `Map`.

```
cs41_staff = {
                 "Parth": "the wonderful",
                 "Antonio": "the bold",
                 "Elizabeth": "the intrepid",
                 "Theo": "the wizard"
                 }
```

Curly braces denote a dictionary.

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cs41_staff = {
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```

Colons separate keys, values; commas separate (key, value) pairs.

Working with Dictionaries

Working with Dictionaries

`val = d[key]`	Access the value in `d` corresponding to `key`; place this value into the `val` variable.

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`val = d[key]`	Access the value in `d` corresponding to `key`; place this value into the `val` variable.
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Working with Dictionaries

`val = d[key]`	Access the value in `d` corresponding to `key`; place this value into the `val` variable.
`d[key] = val`	Set the value in the dictionary corresponding to `key` equal to the value within `val`.
`d.get(key, default)`	Returns the value associated with `key` in `d`. If `key` does not exist in `d`, return `default`.

Working with Dictionaries

`val = d[key]`	Access the value in `d` corresponding to `key`; place this value into the `val` variable.
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`d.keys()`	Returns a collection of the keys in the dictionary.

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`d.keys()`	Returns a collection of the keys in the dictionary.
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`d.items()`	Returns a collection of (key, value) tuples in `d`.

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`del d[key]`	Removes `key`, and its associated value, from `d`. (If key is not in `d`, raises a `ValueError`).

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`del d[key]`	Removes `key`, and its associated value, from `d`. (If key is not in `d`, raises a `ValueError`).
`d.pop(key, default)`	Removes `key`, and its associated value, from `d`. (Returns the associated value if `key` is in `d`, otherwise returns default).

Common Dictionary Operations

Common Dictionary Operations

`len(d)`	Returns the number of keys in `d`.

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Common Dictionary Operations

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`key in d`	Equivalent to `key in d.keys()`
`d.copy()`	Makes a shallow copy of `d`.
`d.clear()`	Removes all (key, value) pairs from `d`.

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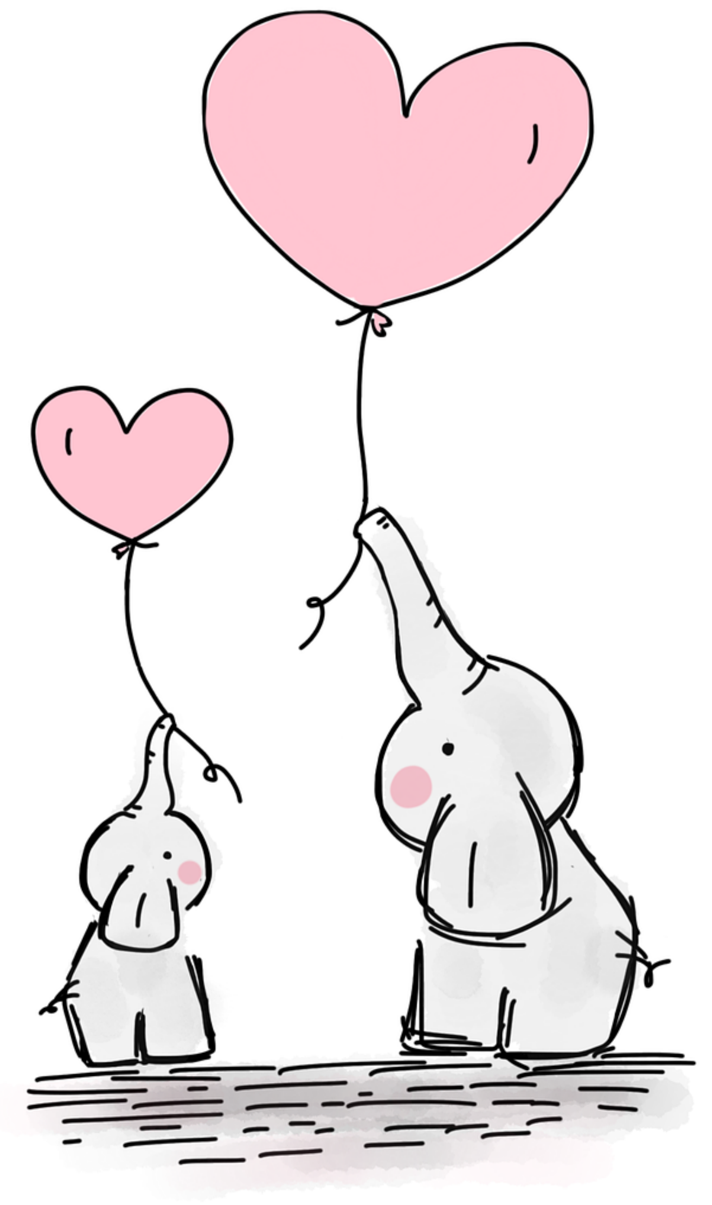

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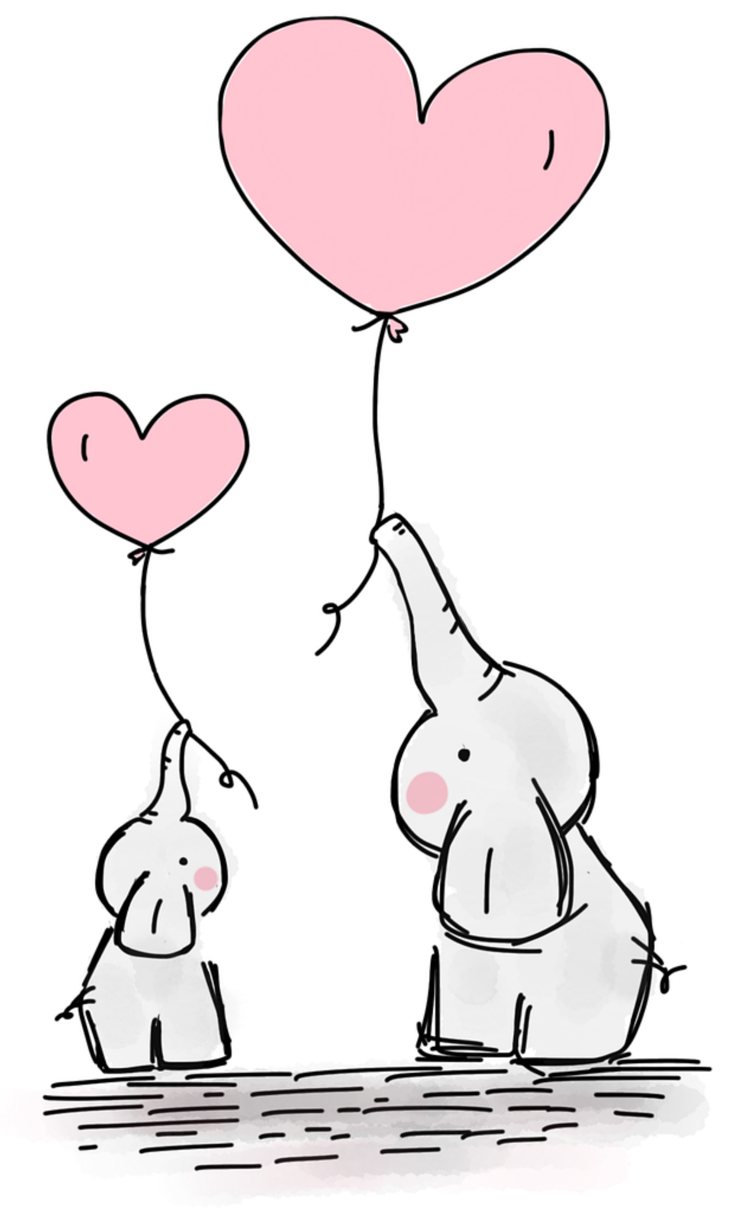

Sets

Set: an unordered collection with no duplicate elements.

```
nice_animals = {"unicorns", "elephants"}
nice_animals = {"unicorns", "elephants"}
```

Curly brackets denote a set!*

```
nice_animals = {"unicorns", "elephants"}
```

Curly brackets denote a set!*

* As long as it's not the empty set, which is denoted `set()`

Why Learn About Sets?

Sets enable:

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- **Fast membership testing** - sets use hashing to enable O(1) membership testing. (List membership testing is O(n)).

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- **Fast membership testing** - sets use hashing to enable O(1) membership testing. (List membership testing is O(n)).
- **O(1) Duplicate Elimination** - can eliminate duplicate entries in a collection.

Why Learn About Sets?

Sets enable:

- **Fast membership testing** - sets use hashing to enable O(1) membership testing. (List membership testing is O(n)).
- **O(1) Duplicate Elimination** - can eliminate duplicate entries in a collection.
- **Efficient Set Operations** - union, intersection, and more of your favourites from set theory!

Basic Set Operations

Basic Set Operations

`s.add(val)`	Adds the value `val` to set `s`.

Basic Set Operations

`s.add(val)`	Adds the value `val` to set `s`.
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Basic Set Operations

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`s.discard(val)`	Removes the value `val` from set `s` if it is present.

Basic Set Operations

`s.add(val)`	Adds the value `val` to set `s`.
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`s.discard(val)`	Removes the value `val` from set `s` if it is present.
`s.pop()`	Remove and return an arbitrary element from s. (Raises `KeyError` if `s` is empty)

Mathematical Set Operations

`s & t`	Set intersection.
`s | t`	Set union.
`s < t`	Check whether `s` is a proper subset of `t`.
`s <= t`	Check whether `s` is a subset of `t`.
`s ^ t`	Symmetric difference.
`s - t`	Set difference.

An interview question: write a program to remove duplicate elements of a list that operates in O(n) time.

`set` **vs.** `frozenset`

- An immutable and hashable set - the elements of a `frozenset` must be hashable for the `frozenset` to be hashable.
  - Can be used - for example - as keys in a dictionary.
- Behaves almost exactly like a regular set, except doesn't support "mutable" operations:
  - `add`
  - `remove`
  - `discard`
  - `pop`

Efficient Phrases

These are efficient phrases:	These are not efficient phrases:
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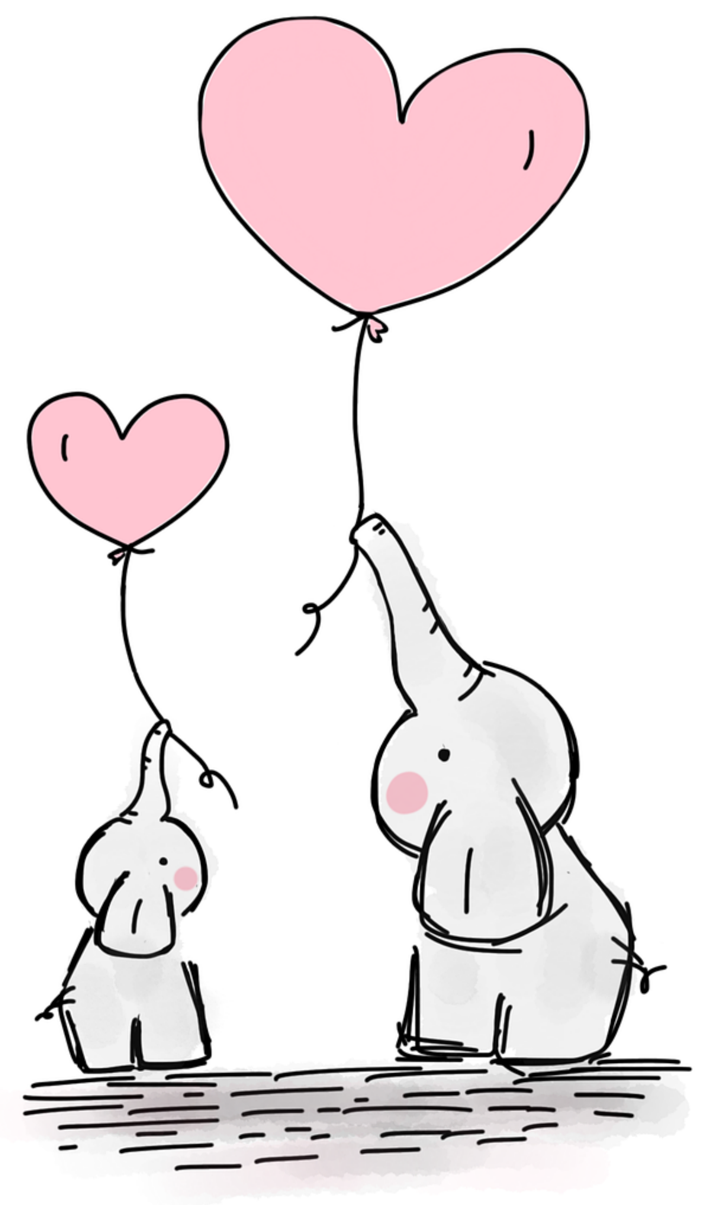
  - ~~Tuples~~
  - ~~Lists~~
  - ~~`range`~~
- ~~Mapping Types~~
  - ~~Dictionaries~~
- Sets
- Advanced Looping
- Comprehensions



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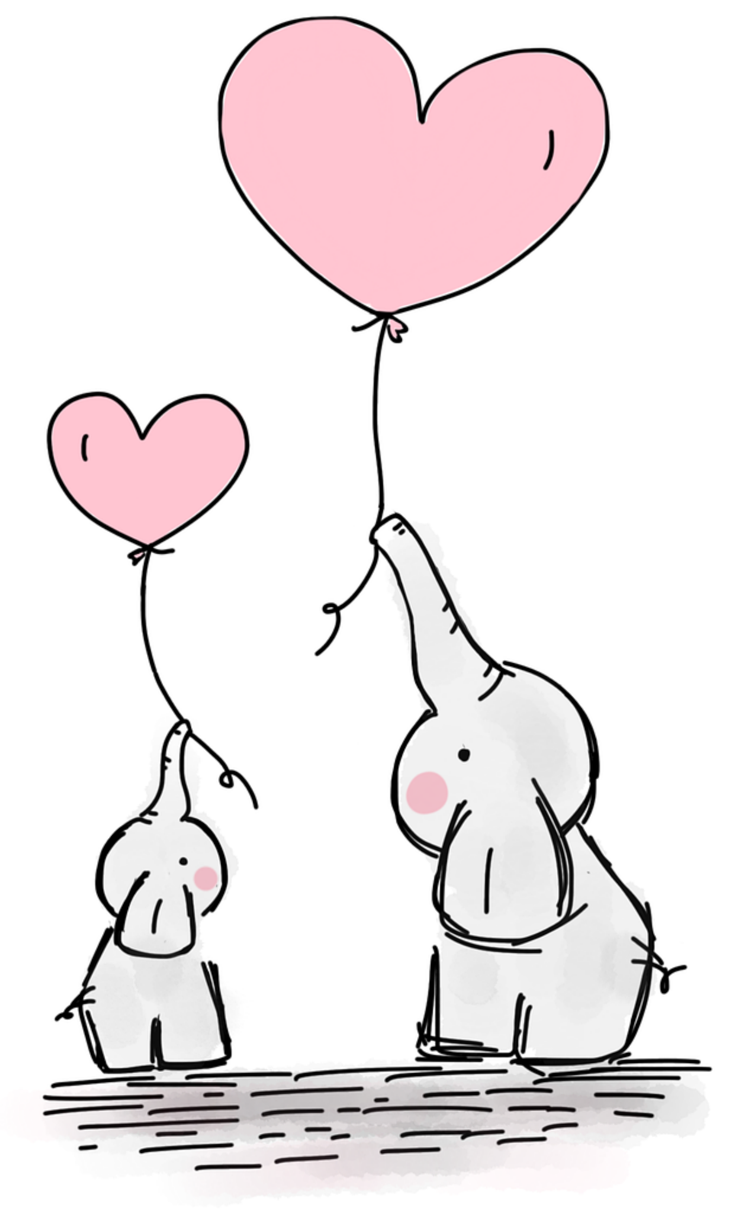

Advanced Looping

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An *iterable* is anything that can be looped over using a `for` loops (`list`, `set`, `dict`, etc.)