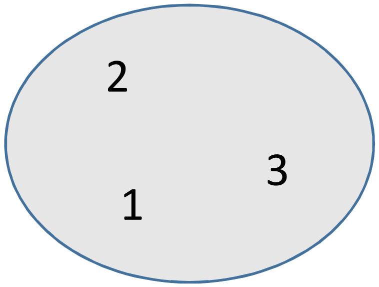
Sets

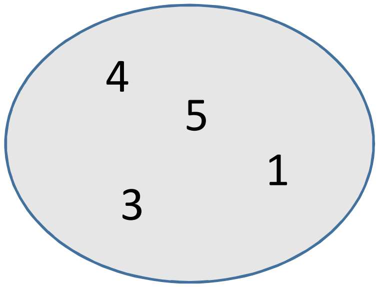
- Mathematical set: a collection of values, without duplicates or order
- Order does not matter

  { 1, 2, 3 } == { 3, 2, 1 }



- No duplicates

  { 3, 1, 4, 1, 5 } == { 5, 4, 3, 1 }



- For every data structure, ask:
  - How to create
  - How to query (look up) and perform other operations
    - (Can result in a new set, or in some other datatype)
  - How to modify

  Answer: http://docs.python.org/3/library/stdtypes.html#set

Two ways to create a set

1. Direct mathematical syntax:

   ```
   odd = {1, 3, 5}
   prime = {2, 3, 5}
   ```

   Note: Cannot use "`{ }`" to express empty set: it means something else ☹. Use `set()` instead.

2. Construct from a **list:** (also from a tuple or string)

   ```
   odd = set([1, 3, 5])
   prime = set([2, 3, 5])
   empty = set([]) # or set()
   ```

Set operations

```
odd = {1, 3, 5}
prime = {2, 3, 5}
```

• membership ∈	Python: `in`	`4 in prime` ⇒ False
• union ∪	Python: `|`	`odd	prime` ⇒ {1, 2, 3, 5}
• intersection ∩	Python: `&`	`odd & prime` ⇒ {3, 5}
• difference \ or -	Python: `-`	`odd - prime` ⇒ {1}

Think in terms of **set operations**,
not in terms of iteration and element operations

- Shorter, clearer, less error-prone, faster

Although we can do iteration over sets:

```
    # iterates over items in arbitrary order
    for item in myset:
      …
```

But we *cannot* index into a set to access a specific element.

Practice with sets

```
z = {5, 6, 7, 8}
y = {1, 2, 3, 1, 5}
k = z & y
j = z | y
m = y - z
n = z - y
```

Modifying a set

- **Add** one element to a set:

```
myset.add(newelt)
myset = myset | {newelt}
```

- **Remove** one element from a set:

```
myset.remove(elt)    # elt must be in myset  or raises error
myset.discard(elt)  # never errors
myset = myset - {elt}
```

What would this do?

```
myset = myset - elt
```

- Remove and return an arbitrary element from a set:

```
myset.pop()
```

Note: `add`, `remove` and `discard` all return **None**

Practice with sets

```
z = {5, 6, 7, 8}
y = {1, 2, 3, 1, 5}
p = z
q = set(z)  # Makes a copy of set z
z.add(9)
q = q | {35}
z.discard(7)
q = q - {6, 1, 8}
```

Aside: List vs. set operations (1)

Find the common elements **in both** list1 and list2:

```
out1 = []
for elem in list2:
    if elem in list1:
        out1.append(elem)
```

Find the common elements **in both** set1 and set2:

```
set1 & set2
```

Much shorter, clearer, easier to write with sets!

Aside: List vs. set operations(2)

Find elements in **either** list1 or list2 (**or both**) (without duplicates):

```
out2 = list(list1)  # make a copy
for elem in list2:
    if elem not in list1: # don’t append elements already in out2
        out2.append(elem)
```

Another way:

```
out2 = list1 + list2   # if an item is in BOTH lists, it will appear TWICE!
for elem in out1:      # out1 = common elements in both lists
    out2.remove(elem) # Remove common elements, leaving just a single copy
```

Find the elements in **either** set1 or set2 (**or both**):

```
set1 | set2
```

Aside: List vs. set operations(3)

Find the elements in **either** list **but <u>not</u> in both**:

```
out3 = []
out2 = list1 + list2  # if an item is in BOTH lists, it will appear TWICE!
for elem in out2:
    if elem not in list1 or elem not in list2:
        out3.append(elem)
```

Find the elements in **either** set **but <u>not</u> in both**:

```
set1 - set2 | set2 - set1
set1 ^ set2
```

Not every value may be placed in a set

- Set *elements* must be **immutable** values
  - int, float, bool, string, *tuple*
  - *not*: list, set, dictionary
- The set itself is **mutable** (e.g. we can add and remove elements)

- **Aside:** *frozenset* must contain immutable values and is itself immutable (cannot add and remove elements)

Why not?

- Goal: only set operations change the set
  - after "`myset.add(x)`", `x in myset` ⇒ True
  - `y in myset` always evaluates to the same value

  Both conditions should hold until `myset` itself is changed
- Mutable elements can violate these goals

`list1 = ["a", "b"]`

`list2 = list1`

`list3 = ["a", "b"]`

`myset = { list1 }` ⇐ **Hypothetical; actually illegal in Python!**

`list1 in myset` ⇒ True

`list3 in myset` ⇒ True

`list2.append("c")` ⇐ not modifying `myset` "directly"

`list1 in myset` ⇒ ??? modifying `myset` "indirectly" would lead to different results

`list3 in myset` ⇒ ???

Thank You

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