Sets

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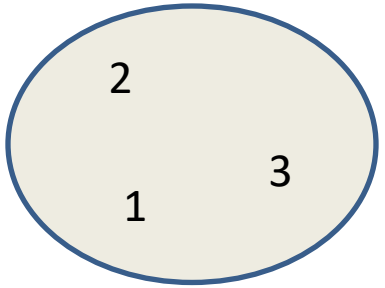
Sets

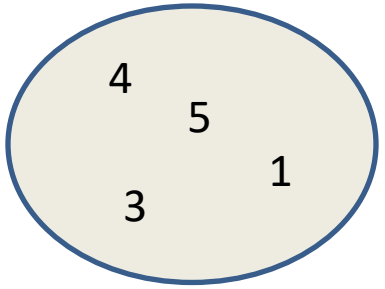
- Mathematical set: a collection of values, without duplicates or order
- Order does not matter

  { 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()
```

See in python tutor

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.

See in python tutor

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`**

See in python tutor

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 not 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 not 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` ⇒ ???