

Composites, Sets: Part 5

A composite type that is a programming implementation of a mathematical set.

James Tam

Sets: An Overview

- When to use:
 - You need a composite where **elements are unique** (not duplicates).
 - Python: adding an element that already exists will fail (no error)
- Another composite where the data can be accessed in different ways:
 - individual elements,
 - the entire collective entity **{ }**
- **Mutable** like a list: elements can change and elements are heterogeneous (don't have to be the same type).
- Associated operations are different from a list (likely because it's not ordered) e.g. indexing, slicing, concatenation, repetition operations are not available.
- Duplicates cannot be added.
 - Attempting to do this via the 'add' method will not add the duplicate element.
 - In this way it provides an automatic form of error prevention (should the data being modeled not allow for duplicates e.g. students in a university).

James Tam

Set Operations

- **Name of the full online example:** 2set_operations.py
- Operations covered in the example: creating a set, iterating, adding, discarding, remove, popping, updating, iterating/creating a set dynamically, membership
- Invalid set operations (not operations in mathematical sets): concatenation, repetition.

James Tam

Creating A Set

- **Format:**
`<name> = {<element1>, <element2>, ... <element n>,}`
- **Example:**
`cpssc231L01Set = {"Humid", "Kin", "Wai"}`
- **Note:** this is not the same syntax as creating a dictionary!
 - Recall: This latter type has a **key** and pair for each element.
`cpssc231L01Dictionary = {1:"Humid",
2:"Kin",
3:"Wai"}`
- **Creating an empty set:**
 - A function must be called: `set()`
`aSet = set() #aSet = {}` Creates a dictionary not a set
`<class 'dict'>`

Note: the later examples occur after a set has already been created.

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Adding New Elements

- Creating elements one at a time.

```
set1 = set()
set1.add("1")
set1.add(True)
set1.add(2)
set1.add(3)
set1.add(3) #Duplicate not added.
```

```
True 2 3 1
```

```
| 1 2 3 True
```

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Iterating Through A Set

```
for element in set1:
    print(element, end=" ")
    3 True 2 1 Recall: it is not ordered
```

```
set1 = set()
set1.add("1")
set1.add(True)
set1.add(2)
set1.add(3)
set1.add(3)
```

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Discarding (A Single) Specified Element

```
set2 = {"Red", "Blue", "Green"}  
set2.discard("Red")
```

- Nothing is discarded if the **element is not already in the set**

```
set2.discard("Orchre")  
{'Blue', 'Green', 'Red'}  
{'Blue', 'Green'}
```

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Removing (A Single) Specified Element

```
set2 = {"Red", "Blue", "Green"}  
set2.remove("Red")
```

- Runtime error results if the element is not already in the set

```
set2.remove("Orcher jelly")  
  
KeyError: 'Orcher jelly'
```

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Popping (Discard) An Element (Randomly Determined)

```
set2 = {"Red", "Blue", "Green"}  
set2.pop() #Run multiple times and different element removed
```

Press enter to see an element popped out of the set

```
{'Red', 'Green'}
```

Press enter to see an element popped out of the set

```
{'Blue', 'Red'}
```

Press enter to see an element popped out of the set

```
{'Red', 'Blue'}
```

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Discarding (A Single) Element

```
set2 = {"Red", "Blue", "Green"}  
set2.discard("Orchre")
```

- Nothing is discarded if the element is not already in the set

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Checking Length

```
set2 = {"Red", "Blue", "Green"}  
len(set2)
```

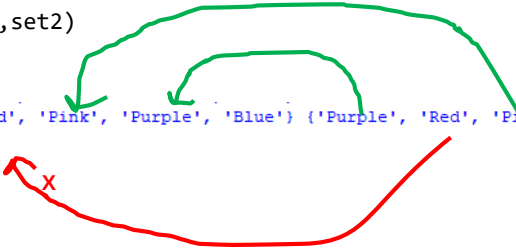
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Updating A Set (Adding One Set To Another)

```
set1 = {"Red", "Blue", "Green"}  
set2 = {"Red", "Pink", "Purple"}  
print(set1, set2)    {'Green', 'Red', 'Blue'} {'Purple', 'Red', 'Pink'}  
set1.update(set2)
```

- Duplicates won't be added.
- The second set (the method argument, in this case set2) will be unchanged.

```
print(set1, set2)  
{'Green', 'Red', 'Pink', 'Purple', 'Blue'} {'Purple', 'Red', 'Pink'}
```



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Iterating And Dynamically Creating New Elements

```
set3 = set()
for i in range(0,4,1):
    set3.add(i)

{0, 1, 2, 3}
|
```

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Checking For Membership (Using The 'In' Operator)

```
set3 = {1,2,3}      {1, 2, 3}
if 1 in set3:      1 in set3
    print("1 in set3")
```

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Why Use Python Sets?

- When mathematical set operations are needed e.g. checking if one set is a superset of another.

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Set Operations

- **Name of the full online example:** `3set_comparisons.py`
- Comparisons covered in the example: intersection, union, symmetric difference, complement difference, subset, superset, equality, inequality, proper subset, proper superset, disjoint sets.

James Tam

Terminology: Superset Vs. Proper Superset

- A proper superset cannot be identical to subset.
- Set1 = {1}, Set2 = {1}
 - Set1 is a superset of Set2
 - Set1 is NOT a proper subset of Set2 because they contain the same values.

```
Is set1 a proper superset of set2?  
{1} {1}  
set1 NOT a proper superset of set2
```

- Set1 = {1,2}, Set2 = {1}
 - Set1 is a subset of Set2
 - Set1 IS a proper subset of Set2 because the values they contain are not identical.

```
Is set1 a proper superset of set2?  
{1, 2} {1}  
set1 a proper superset of set2
```

James Tam

Other Set Comparisions

- Equality
if(set1 == set2):
- Inequality (not equal)
if(set1 != set2):
- Disjoint (do not share an element)

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Intersection ($A \cap B$)

```
set1 = {1}  
set2 = {1,2}  
set3 = set1 & set2
```

```
Intersection of set1, set2  
{1} {1, 2}  
{1}
```

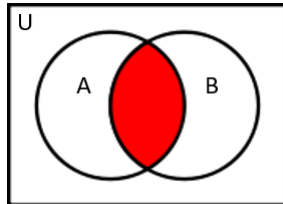


Image: Richard Zhao, Jonathan Hudson

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Union ($A \cup B$)

```
set1 = {1}  
set2 = {1,2}  
set3 = set1 | set2
```

```
Union of set1, set2  
{1} {1, 2}  
{1, 2}
```

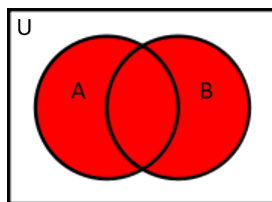


Image: Richard Zhao, Jonathan Hudson

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Symmetric Difference ($A \triangle B$)

The symmetric difference of Set1 and Set2 is the set of elements which are in either of Set1 and Set2, but not in their intersection.

```
set1 = {1,2,3}  
set2 = {3,4}  
set3 = set1 ^ set2
```

```
Symmetric difference of set1, set2  
{1, 2, 3} {3, 4}  
{1, 2, 4}
```

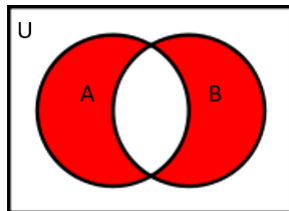


Image: Richard Zhao, Jonathan Hudson

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Complement Difference ($B \setminus A$)

$$A^c \cap B$$

Set subtraction

```
set1 = {1,2,3}  
set2 = {3,4}  
set3 = set1 - set2
```

```
Complement difference of set1, set2  
{1, 2, 3} {3, 4}  
{1, 2}
```

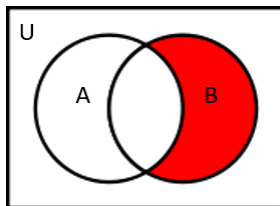


Image: Richard Zhao, Jonathan Hudson

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Subset

```
set1 = {1}  
set2 = {1,2}
```

```
if(set1.issubset(set2)):  
OR  
if(set1 <= set2):
```

```
Is set1 a subset of set2?  
{1} {1, 2}  
issubset: set1 is a subset of set2  
<=: set1 is a subset of set2
```

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Superset

```
set1 = {1}  
set2 = {1,2}
```

```
if(set1.issuperset(set2)):  
OR  
if(set1 >= set2):
```

```
Is set1 a superset of set2?  
{1} {1, 2}  
issuperset: set1 is NOT a superset of set2  
>=: set1 is NOT a superset of set2
```

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Equality

```
set1 = {1}  
set2 = {1,2}
```

```
if(set1 == set2):
```

```
Equality test: Is set1 equal to set2?  
{1} {1, 2}  
set1 is NOT equal to set2
```

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Inequality

```
set1 = {1}  
set2 = {1,2}
```

```
if(set1 != set2):
```

```
Inequality test: Is set1 NOT equal to set2?  
{1} {1, 2}  
set1 is not equal to set2
```

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Proper Subset

```
set1 = {1}  
set2 = {1,2}
```

```
if((set1 <= set2) and (set1 != set2)):  
OR  
if(set1 < set2):
```

```
Is set1 a proper subset of set2?  
{1} {1, 2}  
set1 a proper subset of set2
```

```
set1 = {1}  
set2 = {1}
```

```
Is set1 a proper subset of set2?  
{1} {1}  
set1 NOT a proper subset of set2
```

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Proper Superset

```
set1 = {1}  
set2 = {1,2}
```

```
if((set1 >= set2) and (set1 != set2)):  
OR  
if(set1 > set2):
```

```
Is set1 a proper superset of set2?  
{1, 2} {1}  
set1 a proper superset of set2
```

```
set1 = {1}  
set2 = {1}
```

```
Is set1 a proper superset of set2?  
{1} {1}  
set1 is NOT a proper superset of set2
```

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Disjoint Sets (Do Not Share Elements)

```
set1 = {1,2}
set2 = {2}
```

```
if(set1.isdisjoint(set2)):
```

```
Is set1 disjoint (don't share elements) from set2?
{1, 2} {2}
The sets DO share elements
```

```
set1 = {1,2}
set2 = {3}
```

```
Is set1 disjoint (does share elements) from set2?
{1, 2} {3}
The sets do NOT share elements
```

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Review Of The Composites

	String	List	Array	Dictionary	Tuple	Set
Method of creation	""	[]	numpy.array() or np.array()	{}	()	{}
Can be heterogeneous?	No	Yes	No	Yes	Yes	Yes
Ordered and index able?	Yes	Yes	Yes	No	Yes	No
Mutable ¹	No	Yes	Yes	Yes	No	Yes
Duplicates allowed?	Yes	Yes	Yes	Keys=no, values=yes	Yes	No

- The simple types covered thus far (int, float, bool) are all immutable.
- The final composite type (classes) is significantly different so it's covered separately (introduced at the end of the term and covered in depth in the next course).

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After This Section You Should Now Know

- Set operations: creating a set, iterating, adding, discarding, remove, popping, updating, checking for length, iterating/creating a set dynamically, membership
- Operations from mathematical sets implemented in python: intersection, union, symmetric difference, complement difference, subset, superset, equality, inequality, proper subset, proper superset, disjoint sets.
- Differences between the composite types covered thus far:
 - How to create (distinguish) between strings, lists, dictionaries, tuples, sets and arrays.
 - Which ones are mutable and which ones are immutable (you should know this for non-composites as well).
 - Which types are ordinal (elements have an ordered) and which ones can be indexed.

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After This Section You Should Now Know (2)

- Differences between the composite types covered thus far (continued):
 - Which ones allow for duplicate elements.
 - Which ones can be heterogeneous (elements don't have to all be of the same type).

James Tam

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