COMP41680

Introduction to Python

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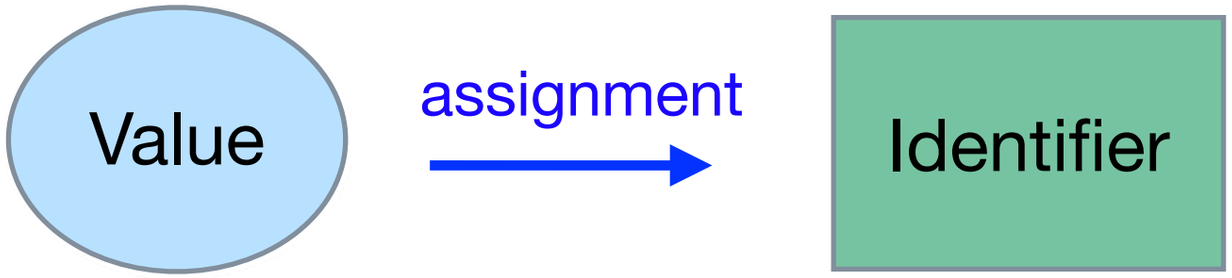
Spring 2023

Variables in Python

- Variable: A container in memory, which has a unique name, where you can store a value.



- In Python we do not need to define variables in advance. Create a variable `x` by assigning it a value, where the = symbol denotes assignment.

```
x = 100
```

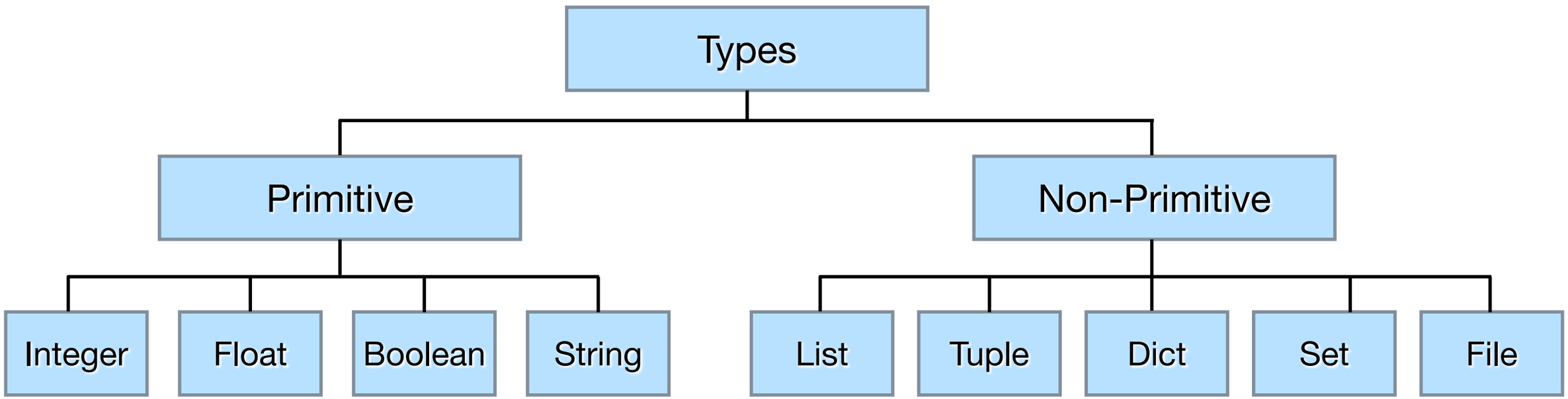
Variable naming rules:

- Can contain both letters and numbers, but must begin with a letter.
- Can contain the underscore character.
- Should not clash with reserved keywords.

Note: Python is a case sensitive language!

Variable Types

- Every variable in Python has a type, indicating the nature of the value that it stores.
- Python types can be divided into two categories:
  - Primitive: Simplest forms of representing data.
  - Non-primitive: These contain primitive values within more complex data structures for special purposes.



Primitive Types

- Four basic primitive Python variable types. These are the building blocks for data manipulation and contain simple values of data.

Integer

```
a = 3
b = -125
```

Float

```
score = 0.452
result = 1e-5
```

Can use decimal or scientific notation

Boolean

```
answer = True
test_val = False
```

True or False. Also interchangeable with the integers 1 and 0

String

```
mytext = "this is some text"
s2 = 'more text'
hello_str = "hello" + " world"
```

Strings can be enclosed in either single or double quotes - but be consistent!

- There is also `None`, the special empty or "null" value

Arithmetic Operators

- Python can be used as a simple calculator. It supports all basic mathematical operators, such as +, -, *, /

```
10 * 2 - 5
```

```
15
```

```
x = 3 * 5
print(x)
```

```
15
```

We can use the *print()* function to display the value of a variable

- Parentheses can be used to control the order in which several operators are applied.

```
4 + 10 / 2
```

```
9.0
```

```
(4 + 10)/2
```

```
7.0
```

Normally division takes precedence over addition

- We can also use operators to perform assignment and an operation on the same variable.

```
x += 2
```

Add 2 to current value of *x*, reassign to *x*

```
x *= 10
```

Multiply current value of *x* by 10, reassign to *x*

Comparison Operators

- Any value or variable can be tested for a truth value. These will yield a value of `True` or `False`, depending on what we are testing.
- A range of different comparison operators can be used to perform these tests - e.g. equality, inequality, greater than etc.

Operator	Description
==	If the values of two operands are equal, then the output is True.
!=	If values of two operands are not equal, then the output is True.
<>	If values of two operands are not equal, then the output is True.
>	If the value of left operand is greater than the value of right operand, then the output is True.
<	If the value of left operand is less than the value of right operand, then the output is True.
>=	If the value of left operand is greater than or equal to the value of right operand, then the output is True.
<=	If the value of left operand is less than or equal to the value of right operand, then the output is True.

Comparison Operators

- Any value or variable can be tested for a truth value. These will yield a value of `True` or `False`, depending on what we are testing.
- A range of different comparison operators can be used to perform these tests - e.g. equality, inequality, greater than etc.

```
y = 80
```

```
y == 80
```
```
True
```
equals

```
y > 10
```
```
True
```
greater than

```
y >= 80
```
```
True
```
greater than or equals

```
y != 80
```
```
False
```
not equals

```
y < 50
```
```
False
```
less than

```
y <= 80
```
```
True
```
less than or equals

- Other operators are provided, such as modulus (%) which is used for finding the remainder on division:

```
10 % 2
```
```
0
```

```
10 % 3
```
```
1
```

```
10 % 4
```
```
2
```

Boolean Operators

- Python contains operators to create more complex logical tests:

`not x`	Evaluates to `True` if x is `False`. Evaluates to `False` if x is `True`
`x and y`	If both x and y are `True` then evaluate to `True`, otherwise `False`
`x or y`	If either x or y are `True` then evaluate to `True`, otherwise `False`

```
not True
```
```
False
```

```
True and True
```
```
True
```

```
True or False
```
```
True
```

```
5 < 10 and 5 < 3
```
```
False
```

```
not False
```
```
True
```

```
True and False
```
```
False
```

```
False or False
```
```
False
```

```
5 < 10 or 5 < 3
```
```
True
```

Calling Functions

- Functions in Python are groups of code that have a name and can be called using parentheses notation:

Function name

Argument values, in parenthesis

- Return value → `res = pow(4, 3)`

e.g. call function `pow()` to calculate 4 raised to the power of 3

- Not all functions require arguments or return a value.

```
print("Hello world!")
```

The function `print()` has no return value

- Python contains a large number of built-in functions that can be called in this way: https://docs.python.org/3/library/functions.html

- Variables in Python can also have functions associated with them. These are called using dot notation:

```
s = "TEST"
t = s.lower()
print(t)
```

Call function `lower()` associated with `s`

```
test
```

Data Structures: Lists

- Lists: An ordered collection of values. The values can have different types.
- Values in a list are accessed by specifying an index (position) using square bracket notation. Indexes start from 0 in Python

```
mylist = [12, 108, 23]
mylist2 = ["text", 7, 0.34, True]
```

```
mylist[0]
```

```
12
```

First value has index 0

```
mylist[-1]
```

```
23
```

Access in reverse via negative numbers

- As well as positional indexing, lists support a more general form of indexing known as slicing, which can extract an entire sub-list.
- Format: `X[i:j]` means “give me everything in `X` from position `i` up to but not including position `j`”.

```
l = [7,6,8,9,1]
l[0:2]
```

```
[7, 6]
```

```
l = [7,6,8,9,1]
l[2:5]
```

```
[8, 9, 1]
```

```
l = [7,6,8,9,1]
l[1:]
```

```
[6, 8, 9, 1]
```

```
l = [7,6,8,9,1]
l[:2]
```

```
[7, 6]
```

Default for `i` is 0, default for `j` is the end of the string

Data Structures: Lists

- Lists can be modified after creation, either by changing existing values, or adding items to the end using the `append()` function.

```
mx = [12, 33, 21]
mx[1] = 108
print(mx)
```

```
[12, 108, 21]
```

Change the 2nd value - i.e. index 1

```
mx = [12, 33, 21]
mx.append(9)
mx.append(13)
print(mx)
```

```
[12, 33, 21, 9, 13]
```

Add two new values to the end of the list

- We can remove the first occurrence of a value from a list using the `remove()` function:

```
x = ["a","b","c"]
x.remove("b")
print(x)
```

```
['a', 'c']
```

- Multiple lists can also be concatenated together to create new lists:

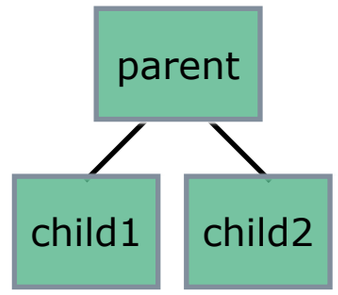
```
[8, 11] + [2, 2] + [0]
```

```
[8, 11, 2, 2, 0]
```

Data Structures: Lists

- Nesting: Lists can be contained inside other lists.
- Values in nested lists can be accessed using multiple indexes in square brackets:

```
child1 = [12, 108, 23]
child2 = [99, 4]
parent = [child1, child2]
```



parent[1][0]	parent[0][2]
99	23

- A variety of built-in functions can be used with lists:

```
x = ["c","a","b"]
len(x)
```

```
3
```

Get number of items in a list

```
x = ["c","a","b"]
x.reverse()
print(x)
```

```
['b', 'a', 'c']
```

Reverse the order of a list

```
x.sort()
print(x)
```

```
['a', 'b', 'c']
```

Sort a list in place

```
x.clear()
print(x)
```

```
[]
```

Remove all items from a list

Data Structures: Tuples

- Tuples are sequences like lists but are "immutable" - i.e. they cannot be changed once they are created.
- They can provide an "integrity constraint" when passing values around a complex program.

```
mycard = ("hearts", "king")
```

Use parenthesis notation to create a tuple

```
print(mycard[1])
```

```
king
```

Positional indexing works the same way as for a list

```
t = (2, True, "ucd")
```

Values can take different types, like a list

- Trying to modify a tuple after creation will cause an error...

```
mycard[1] = "queen"
```

```
TypeError: 'tuple' object does
not support item assignment
```

```
t[0] = 12
```

```
TypeError: 'tuple' object does
not support item assignment
```

Data Structures: Sets

- Set: An unordered collection which contains no duplicate values. A set does not have an order, so it cannot be indexed by position.
- Sets can be created using curly bracket notation. They can also be created from lists, strings or any other iterable value, using the `set()` function.

Create a new non-empty set using curly bracket notation

```
goals = {3, 0, 1, 2}
goals
```

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

Sets can contain values of different types

```
mix = {"UCD", 2000, True, 15.6}
```

To create an empty set, call set() with no argument

```
x = set()
```

Convert specified list into a set, duplicate values are removed

```
mylist = [1,3,1,4,3,6,8,1,4,4]
set(mylist)
```

```
{1, 3, 4, 6, 8}
```

Data Structures: Sets

- Sets can be modified after creation. To add a single value to a set, we call its `add()` function.
- To add multiple values to a set, we call its `update()` function.

```
x = {1, 3, 5}
x.add(7)
x.add(9)
print(x)
```

```
{1, 3, 5, 7, 9}
```

```
x = {"a", "z"}
x.update([10,20])
print(x)
```

```
{'a', 10, 'z', 20}
```

- A number of functions can be used to combine and compare sets:

```
x = {1,2,3,4}
y = {3,4,5}
```

```
x.intersection(y)
```

```
{3, 4}
```

Values in both x and y

```
x.union(y)
```

```
{1, 2, 3, 4, 5}
```

Values in either x or y

```
x.difference(y)
```

```
{1, 2}
```

Values in x but not y

The `in` operator can be used to check if a value is in a set.

```
1 in x
```

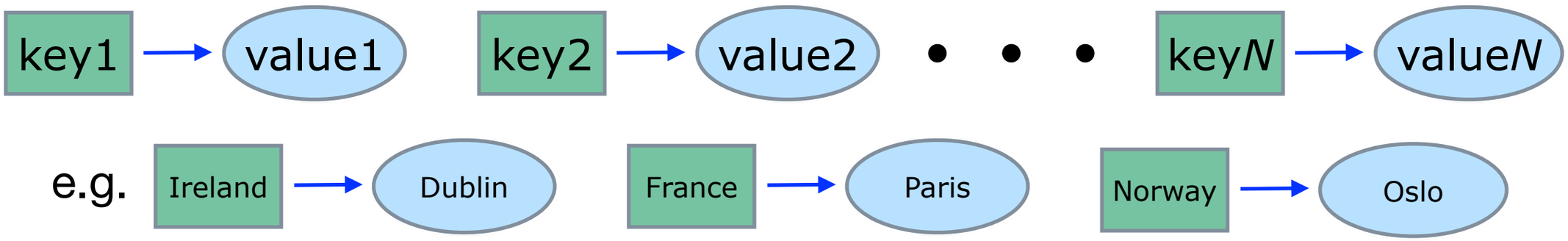
```
True
```

```
7 in x
```

```
False
```

Data Structures: Dictionaries

- Data structure used to store a map of (key:value) pairs



Create an empty dictionary

```
d0 = {}
```

Create and populate a new dictionary

```
d1 = {"Ireland":"Dublin", "France":"Paris"}
```

Access a value in a dictionary

```
d1["Ireland"]
```

```
Dublin
```

Trying to access non-existent key causes an error

```
d1["Norway"]
```

```
KeyError: 'Norway'
```

Check for the presence of a key using the `in` operator

```
"Ireland" in d1
```

```
True
```

```
"Norway" in d1
```

```
False
```

Data Structures: Dictionaries

- Dictionaries can be modified after creation. New pairs can easily be added using the assignment operator:

```
d1["Italy"] = "Rome"
```

```
{'Ireland': 'Dublin', 'France': 'Paris', 'Italy': 'Rome'}
```

- Dictionaries have various associated functions to access the keys and/or values.

Get only the keys from a dictionary

```
d1.keys()
```

```
dict_keys(['Ireland', 'France', 'Italy'])
```

Get only the values from a dictionary

```
d1.values()
```

```
dict_values(['Dublin', 'Paris', 'Rome'])
```

Get all (key, value) pairs as tuples

```
d1.items()
```

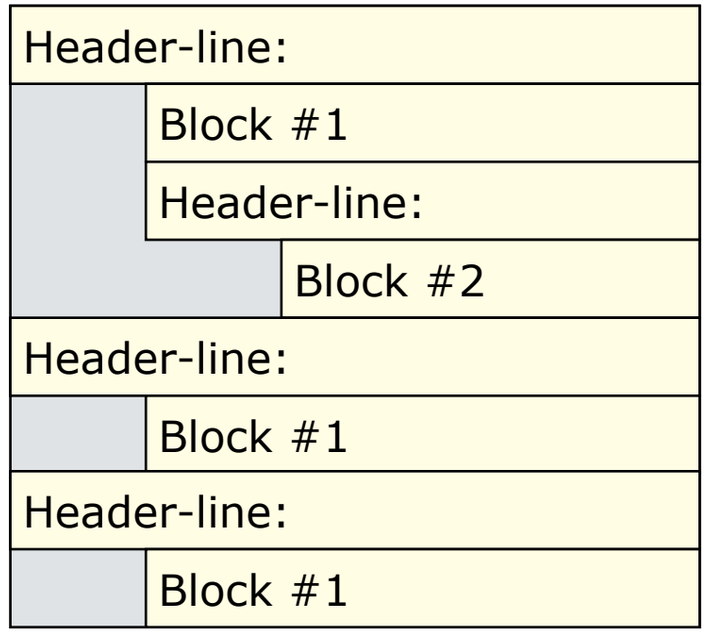
```
dict_items([('Ireland', 'Dublin'), ('France', 'Paris'),
('Italy', 'Rome')])
```

Blocks and Indentation

- Block: A collection of contiguous statements to be executed one after another.
- Indentation: Tabs or spaces appearing at the start of a line of code.
- Unlike most programming languages, indentation is significant in Python - it is used to denote the beginning and end of block structures....

- **Task A**
  - Some actions
  - Sub-task
    - Some actions
- **Task B**
  - Some actions
- **Task C**
  - Some actions

Use indentation to denote nested blocks of code.



Blocks and Indentation

- In Python there is no need to mark block boundaries.
  - Python automatically detects these based on line indentation.
- The indentation level of statements is significant.
  - The exact amount of indentation does not matter, only the relative indentation of the blocks.
- Makes code less verbose and improves readability.

```
while x < 10:
    print("x is currently", x)
    x = x + 1
    if x > 5:
        print("x approaching 10")
```

Colon character at end of block header line

Outer block

Inner block 1

Inner block 2

Flow Control: Conditionals

- If statements: Select code to execute based on a specified Boolean expression (i.e. is the expression `True` or `False`).
- If the condition is true, we run a block of statements (called an *if-block*), else we process another block of statements (called an *else-block*). The else clause is optional.

General Format

```
if <condition1>:
   <block1>
elif <condition2>:
   <block2>
else:
   <block3>
```

First branch

Alternative branch

"Last resort"

```
x = 3
y = 4
if x < y:
    print("y is greater")
elif x == y:
    print("values are equal")
else:
    print("x is greater")
```

```
y is greater
```

Flow Control: Conditionals

- If statements: Select code to execute based on a specified Boolean expression (i.e. is the expression `True` or `False`).

```
if guess == answer:
    print("Congratulations. You guessed it.")
elif guess < answer:
    print("No. It is a higher than that.")
else:
    print("No. It is a lower than that.")
print("Done.")
```

Block for first branch

Block for second branch

Block for third branch

This block of code always gets executed

Conditions can be combined using logical operators:

```
if x < 3 and y > 7:
    print("Both true")
```

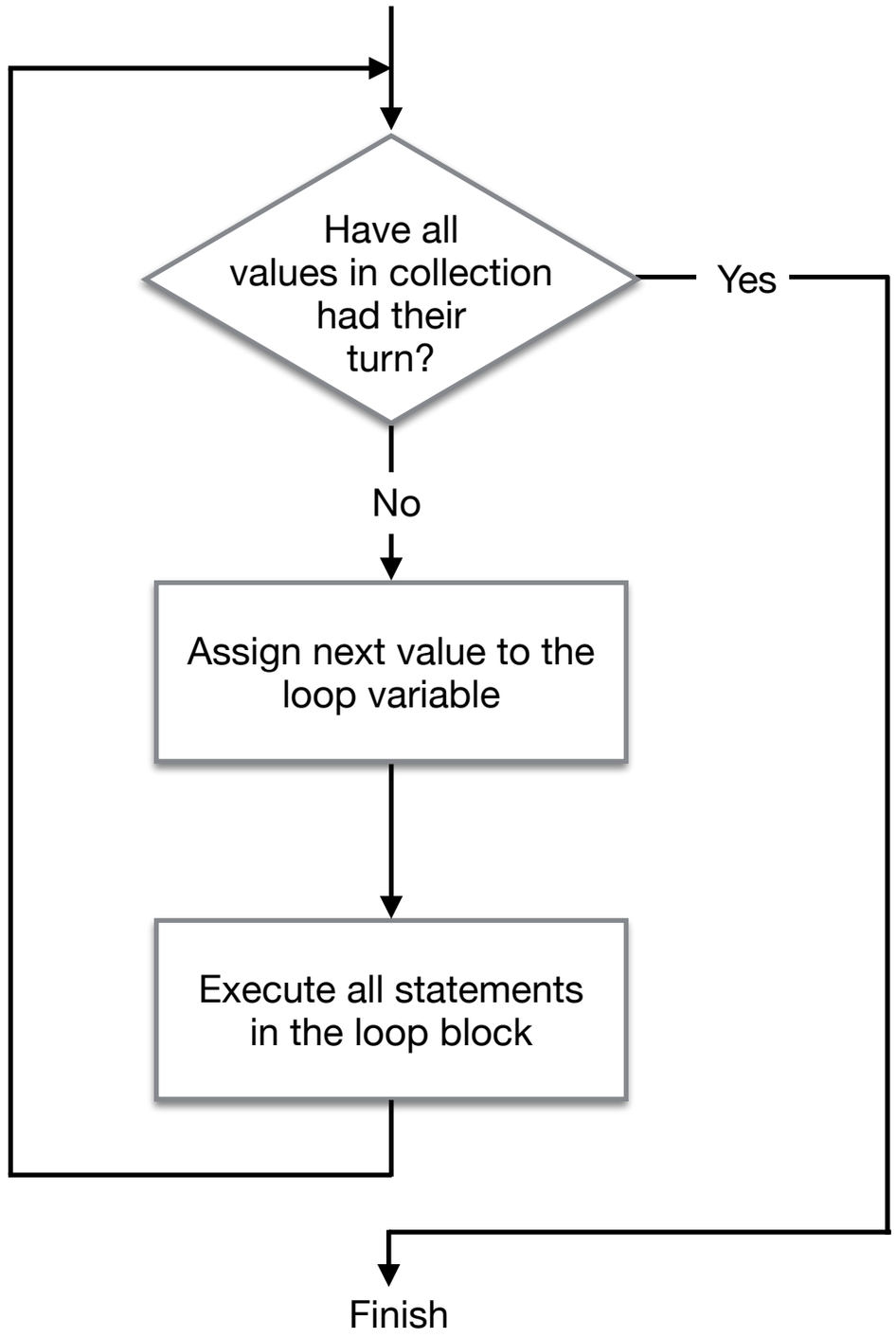
```
if ( x < 3 and y > 7 ) or x == y:
    print("Evaluated to true")
```

Flow Control: For Loops

- For loops: Iterate over a collection of values, and repeatedly apply a block of code to each value in the collection.
- Loops can be applied to the items in any collection or other iterable object
  e.g. lists, tuples, sets, or functions that generate sequences of values

General Format

```
for <value> in <collection>:
    <block>
```



Flow Control: For Loops

- Loops can be applied to the items in any ordered sequence or other iterable object - e.g. lists, tuples, sets, or functions that generate sequences

Variable *v* takes value of each item in the list *names*

Indented block of code to apply to each element

```
names = ["John","Mark","Jane"]
for v in names:
    print("Hello", v)
```

```
Hello John
Hello Mark
Hello Jane
```

Iterate over the keys in the dictionary

```
capitals = {"Ireland":"Dublin", "France":"Paris"}
for country in capitals:
    print( country, "->", capitals[country] )
```

```
Ireland -> Dublin
France -> Paris
```

Flow Control: For Loops

- Generating lists with a specific number of integers is a common task, particularly when using a For loop. The range() function can easily generate sequences of numbers.

Passing a single argument *n* gives *n* values starting at 0

```
for x in range(4):
    print("Value is", x)
```

```
Value is 0
Value is 1
Value is 2
Value is 3
```

Passing 2 arguments specifies the starting value and the value to stop before.

```
for x in range(11,15):
    print("Value is", x)
```

```
Value is 11
Value is 12
Value is 13
Value is 14
```

Passing 3 arguments specifies the starting value, value to stop before, and the step size.

```
for x in range(5,12,3):
    print("Value is", x)
```

```
Value is 5
Value is 8
Value is 11
```

Flow Control: While Loops

- While loops: Repeatedly execute a block of code while a specified Boolean expression still evaluates to `True`.

General Format
`while <condition>:` `    <block>`

Condition

Indented block

```
x = 5
while x < 8:
    print("x is currently", x)
    x = x + 1
```

```
x is currently 5
x is currently 6
x is currently 7
```

- Special keywords can be used to control the execution of a loop...
  - break: Jump out of enclosing loop
  - continue: Jump to top of enclosing loop
  - pass: Do nothing (empty statement).

```
while x < 8:
    if x%2 == 0:
        break
    x = x + 1
```