Watch by Thursday, October 15, 2020 | **Lesson #4**

Control flow

`For` loops, `while` loops, list comprehensions, and `if` statements

OCEAN 215 | Autumn 2020

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What we'll cover in this lesson

1. **`For` loops**
2. Advanced `for` loops
3. `While` loops and list comprehensions
4. `If` statements

Why use loops when programming?

Sometimes we want to do something repetitive:

```python
temperatures = [68.5,72.1,74.8,65.3,62.7,58.9]
print(temperatures[0])
print(temperatures[1])
print(temperatures[2])
print(temperatures[3])
print(temperatures[4])
print(temperatures[5])
```

```
68.5
72.1
74.8
65.3
62.7
58.9
```

Why use loops when programming?

Sometimes we want to do something repetitive:

```
1 print(temperatures[0])
2 print(temperatures[1])
3 print(temperatures[2])
4 print(temperatures[3])
5 print(temperatures[4])
6 print(temperatures[5])
7 print(temperatures[6])
8 print(temperatures[7])
9 print(temperatures[8])
10 print(temperatures[9])
11 print(temperature[10])
12 print(temperatures[11])
13 print(temperatures[12])
14 print(temperatures[13])
15 print(temperatures[14])
16 print(temperatures[15])
17 print(temperatures[16])
18 print(temperatures[17])
19 print(temperatures[18])
20 print(temperatures[19])
21 print(temperatures[20])
22 print(temperatures[21])
23 print(temperatures[22])
24 print(temperatures[23])
25 print(temperatures[24])
26 print(temperatures[25])
27 print(temperatures[26])
28 print(temperatures[27])
29 print(temperatures[28])
30 print(temperatures[29])
31 print(temperatures[30])
32 print(temperatures[31])
33 print(temperatures[32])
34 print(temperatures[33])
35 print(temperatures[34])
36 print(temperatures[35])
37 print(temperatures[36])
38 print(temperatures[37])
39 print(temperatures[38])
40 print(temperatures[39])
41 print(temperatures[40])
42 print(temperatures[41])
43 print(temperatures[42])
44 print(temperatures[43])
45 print(temperatures[44])
46 print(temperatures[45])
47 print(temperatures[46])
48 print(temperatures[47])
49 print(temperatures[48])
50 print(temperatures[49])
```

```
51 print(temperatures[50])
52 print(temperatures[51])
53 print(temperatures[52])
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55 print(temperatures[54])
56 print(temperatures[55])
57 print(temperatures[56])
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61 print(temperatures[60])
62 print(temperatures[61])
63 print(temperatures[62])
64 print(temperatures[63])
65 print(temperatures[64])
66 print(temperatures[65])
67 print(temperatures[66])
68 print(temperatures[67])
69 print(temperatures[68])
70 print(temperatures[69])
71 print(temperatures[70])
72 print(temperatures[71])
73 print(temperatures[72])
74 print(temperatures[73])
75 print(temperatures[74])
76 print(temperatures[75])
77 print(temperatures[76])
78 print(temperatures[77])
79 print(temperatures[78])
80 print(temperatures[79])
81 print(temperatures[80])
82 print(temperatures[81])
83 print(temperatures[82])
84 print(temperatures[83])
85 print(temperatures[84])
86 print(temperatures[85])
87 print(temperatures[86])
88 print(temperatures[87])
89 print(temperatures[88])
90 print(temperatures[89])
91 print(temperatures[90])
92 print(temperatures[91])
93 print(temperatures[92])
94 print(temperatures[93])
95 print(temperatures[94])
96 print(temperatures[95])
97 print(temperatures[96])
98 print(temperatures[97])
99 print(temperatures[98])
100print(temperatures[99])
```

Why use loops when programming?

Sometimes we want to do something repetitive:

```
print(temperatures[0])
print(temperatures[1])
print(temperatures[2])
print(temperatures[3])
print(temperatures[4])
print(temperatures[5])
print(temperatures[6])
print(temperatures[7])
print(temperatures[8])
print(temperatures[9])
print(temperature[10])
print(temperatures[11])
print(temperatures[12])
print(temperatures[13])
print(temperatures[14])
print(temperatures[15])
print(temperatures[16])
print(temperatures[17])
print(temperatures[18])
print(temperatures[19])
print(temperatures[20])
print(temperatures[21])
print(temperatures[22])
print(temperatures[23])
print(temperatures[24])
print(temperatures[25])
print(temperatures[26])
print(temperatures[27])
print(temperatures[28])
print(temperatures[29])
print(temperatures[30])
print(temperatures[31])
print(temperatures[32])
print(temperatures[33])
print(temperatures[34])
print(temperatures[35])
print(temperatures[36])
print(temperatures[37])
print(temperatures[38])
print(temperatures[39])
print(temperatures[40])
print(temperatures[41])
print(temperatures[42])
print(temperatures[43])
print(temperatures[44])
print(temperatures[45])
print(temperatures[46])
print(temperatures[47])
print(temperatures[48])
print(temperatures[49])
```

Oops.

```
print(temperatures[50])
print(temperatures[51])
print(temperatures[52])
print(temperatures[53])
print(temperatures[54])
print(temperatures[55])
print(temperatures[56])
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print(temperatures[61])
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print(temperatures[63])
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print(temperatures[65])
print(temperatures[66])
print(temperatures[67])
print(temperatures[68])
print(temperatures[69])
print(temperatures[70])
print(temperatures[71])
print(temperatures[72])
print(temperatures[73])
print(temperatures[74])
print(temperatures[75])
print(temperatures[76])
print(temperatures[77])
print(temperatures[78])
print(temperatures[79])
print(temperatures[80])
print(temperatures[81])
print(temperatures[82])
print(temperatures[83])
print(temperatures[84])
print(temperatures[85])
print(temperatures[86])
print(temperatures[87])
print(temperatures[88])
print(temperatures[89])
print(temperatures[90])
print(temperatures[91])
print(temperatures[92])
print(temperatures[93])
print(temperatures[94])
print(temperatures[95])
print(temperatures[96])
print(temperatures[97])
print(temperatures[98])
print(temperatures[99])
```

Why use loops when programming?

Sometimes we want to
do so

```
1 print(temperatures[0])
2 print(temperatures[1])
3 print(temperatures[2])
4 print(temperatures[3])
5 print(temperatures[4])
6 print(temperatures[5])
7 print(temperatures[6])
8 print(temperatures[7])
```

```
51 print(temperatures[50])
52 print(temperatures[51])
53 print(temperatures[52])
54 print(temperatures[53])
55 print(temperatures[54])
56 print(temperatures[55])
57 print(temperatures[56])
58 print(temperatures[57])
```

There's a more efficient way.

Loops allow you to repeat an action, *efficiently*.

```
35 print(temperatures[34])
36 print(temperatures[35])
37 print(temperatures[36])
38 print(temperatures[37])
39 print(temperatures[38])
40 print(temperatures[39])
41 print(temperatures[40])
42 print(temperatures[41])
43 print(temperatures[42])
44 print(temperatures[43])
45 print(temperatures[44])
46 print(temperatures[45])
47 print(temperatures[46])
48 print(temperatures[47])
49 print(temperatures[48])
50 print(temperatures[49])
```

```
85 print(temperatures[84])
86 print(temperatures[85])
87 print(temperatures[86])
88 print(temperatures[87])
89 print(temperatures[88])
90 print(temperatures[89])
91 print(temperatures[90])
92 print(temperatures[91])
93 print(temperatures[92])
94 print(temperatures[93])
95 print(temperatures[94])
96 print(temperatures[95])
97 print(temperatures[96])
98 print(temperatures[97])
99 print(temperatures[98])
100print(temperatures[99])
```

Elements of the Python `for` loop

```
for <VARIABLE> in <ITERABLE>:
    <ACTION>
    <ACTION>
    etc.
```

Elements of the Python `for` loop

You should give this variable a unique name

In Python, iterables are collections of objects

```
for <VARIABLE> in <ITERABLE>:
    <ACTION>
    <ACTION>
    etc.
```

The colon is essential!

Actions that you want to repeat can be any line of code, such as `print` statements, variable assignments, or calculations

Indent using a **tab** or **2 spaces** (on Google Colab)

Iterables that you can use in `for` loops

`list`	`[4,3,2,1]`
`tuple`	`('pH','puget_sound',7.8)`
`string`	`'hello'`
`range()`	`range(0,7,2)`
`enumerate()`	stay tuned...
`zip()`	stay tuned...

and others...

Iterables that you can use in `for` loops

`list`	`[4,3,2,1]`
`tuple`	`('pH','puget_sound',7.8)`
`string`	`'hello'`
`range()`	`range(0,7,2)` a.k.a. `[0,2,4,6]`
`enumerate()`	stay tuned...
`zip()`	stay tuned...

and others...

Iterables that you can use in `for` loops

Variable names are okay to use in loops, too:

`list`	`countdown`
`tuple`	`pH_data`
`string`	`hello_string`
`range()`	`even_numbers`
`enumerate()`	stay tuned...
`zip()`	stay tuned...

and others...

Examples of `for` loops

Option 1:

```
for item in [4,3,2,1]:
  print(item)
```

```
4
3
2
1
```

Option 2:

```
countdown = [4,3,2,1]

for item in countdown:
  print(item)
```

```
4
3
2
1
```

Examples of `for` loops

Option 1:

```
for value in ('pH','puget_sound',7.8):
  print(value)
```

```
pH
puget_sound
7.8
```

Option 2:

```
pH_data = ('pH','puget_sound',7.8)

for value in pH_data:
  print(value)
```

```
pH
puget_sound
7.8
```

Examples of `for` loops

Option 1:

```
for character in 'hello':
  print(character)
```

```
h
e
l
l
o
```

Option 2:

```
hello_string = 'hello'

for character in hello_string:
  print(character)
```

```
h
e
l
l
o
```

Examples of `for` loops

Option 1:

```
for index in range(0,7,2):
  print(index)
```

```
0
2
4
6
```

Option 2:

```
even_numbers = range(0,7,2)

for index in even_numbers:
  print(index)
```

```
0
2
4
6
```

Using a `for` loop to calculate a sum of numbers

Option 1:

```
numbers = [5,6,7,8]
sum = 0

for value in numbers:
  sum = sum + value

print('The sum is:',sum)
```

```
The sum is: 26
```

Using a `for` loop to calculate a sum of numbers

Option 2:

```
numbers = [5,6,7,8]
sum = 0

for value in numbers:
  sum += value

print('The sum is:',sum)
```

Assignment operator:

`a += b`

is equivalent to:

`a = a + b`

```
The sum is: 26
```

Using a `for` loop to calculate a sum of numbers

Option 3:

```
numbers = [5,6,7,8]
sum = 0

for index in range(len(numbers)):
  sum += numbers[index]

print('The sum is:',sum)
```

`range(4)` a.k.a. `[0,1,2,3]`

```
The sum is: 26
```

What we'll cover in this lesson

1. `For` loops
2. **Advanced `for` loops**
3. `While` loops and list comprehensions
4. `If` statements

Nested `for` loops

```
1 params = ['Temperature','Salinity','Oxygen']
2 units = ['°C','PSU','µmol/kg']
3 currents_mix = [[4.4,4.8,4.5],    # temp (°C)
4                 [34.5,33.9,33.8], # salinity (PSU)
5                 [230,250,260]]    # oxygen (µmol/kg)
6
7 n_params = len(currents_mix)         # 3 parameters
8 n_currents = len(currents_mix[0])    # 3 currents
```

Mix seawater from 3 locations.

What is the average temperature, salinity, and oxygen?

Nested `for` loops

```
1 params = ['Temperature','Salinity','Oxygen']
2 units = ['°C','PSU','µmol/kg']
3 currents_mix = [[4.4,4.8,4.5],     # temp (°C)
4                 [34.5,33.9,33.8], # salinity (PSU)
5                 [230,250,260]]    # oxygen (µmol/kg)
6
7 n_params = len(currents_mix)          # 3 parameters
8 n_currents = len(currents_mix[0])     # 3 currents
9
10 for param_idx in range(n_params):
11   sum = 0.0
12
13   for current_idx in range(n_currents):
14     sum += currents_mix[param_idx][current_idx]
15
16   average_val = sum / n_currents
17   print(params[param_idx] + ' (' + units[param_idx] + '):',average_val)
```

Outer `for` loop

Inner `for` loop

Indent!

Nested `for` loops

Cycle	Outer loop's `param_idx`	Inner loop's `current_idx`	`currents_mix[param_idx][current_idx]`	
#1	0	0	4.4	Temperature
#2	0	1	4.8	
#3	0	2	4.5	
#4	1	0	34.5	Salinity
#5	1	1	33.9	
#6	1	2	33.8	
#7	2	0	230	Oxygen
#8	2	1	250	
#9	2	2	260	

Nested `for` loops

Cycle	Outer loop's `param_idx`	Inner loop's `current_idx`	`currents_mix[param_idx][current_idx]`
#1	0	0	4.4
#2	0	1	4.8
#7	2	0	230
#8	2	1	250
#9	2	2	260

Temperature

Oxygen

```
Temperature (°C): 4.566666666666666
Salinity (PSU): 34.06666666666667
Oxygen (μmol/kg): 246.6666666666666
```

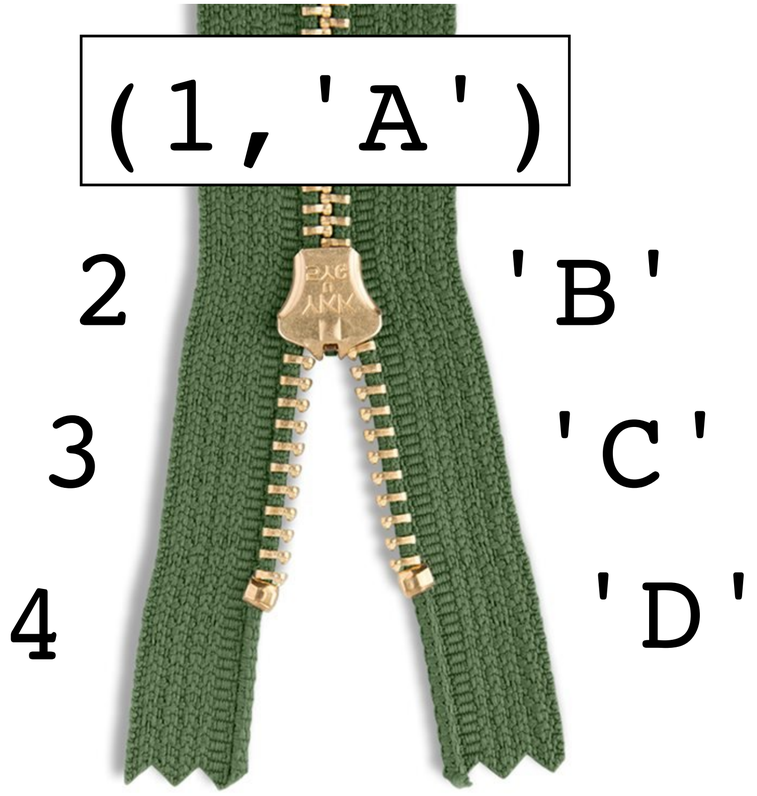
Looping using the `zip()` function

`zip()` joins multiple iterators (e.g. lists) and returns an iterable of tuples.

Those tuples get unpacked when looping over the `zip` object.

```
x = [1,2,3,4]
y = ['A','B','C','D']

zip(x,y)
```



Looping using the `zip()` function

`zip()` joins multiple iterators (e.g. lists) and returns an iterable of tuples. Those tuples get unpacked when looping over the `zip` object.

```
1 params = ['Temperature','Salinity','Oxygen']
2 units = ['°C','PSU','µmol/kg']
3
4 for param, unit in zip(params,units):
5   print(param,'has units of',unit)
```

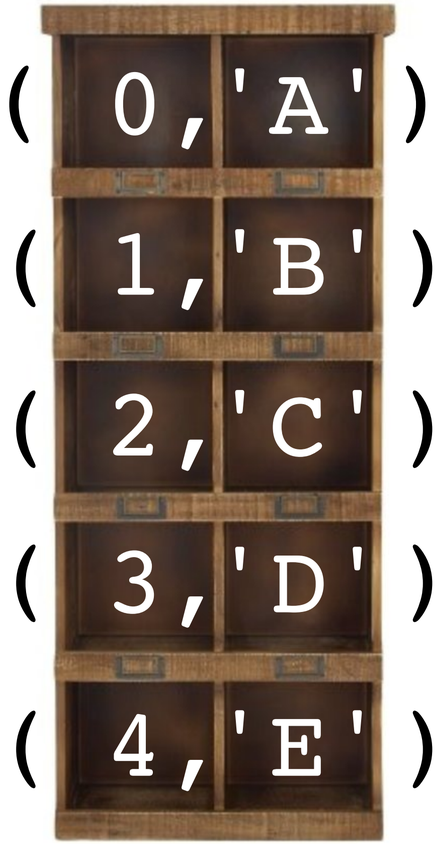
```
Temperature has units of °C
Salinity has units of PSU
Oxygen has units of µmol/kg
```

Looping using the `enumerate()` function

`enumerate()` takes an iterable (e.g. a list) as an argument and returns an iterable of tuple pairs of `(index,value)`. Index starts counting from 0.

```
x = ['A','B','C','D','E']

enumerate(x)
```



Looping using the `enumerate()` function

`enumerate()` takes an iterable (e.g. a list) as an argument and returns an iterable of tuple pairs of `(index,value)`. Index starts counting from 0.

```
abbrevs = ['POC','DOC','DIC']
names = ['particulate organic carbon',
         'dissolved organic carbon',
         'dissolved inorganic carbon']

for index, abbrev in enumerate(abbrevs):
  print(abbrev,'stands for',names[index])
```

```
POC stands for particulate organic carbon
DOC stands for dissolved organic carbon
DIC stands for dissolved inorganic carbon
```

What we'll cover in this lesson

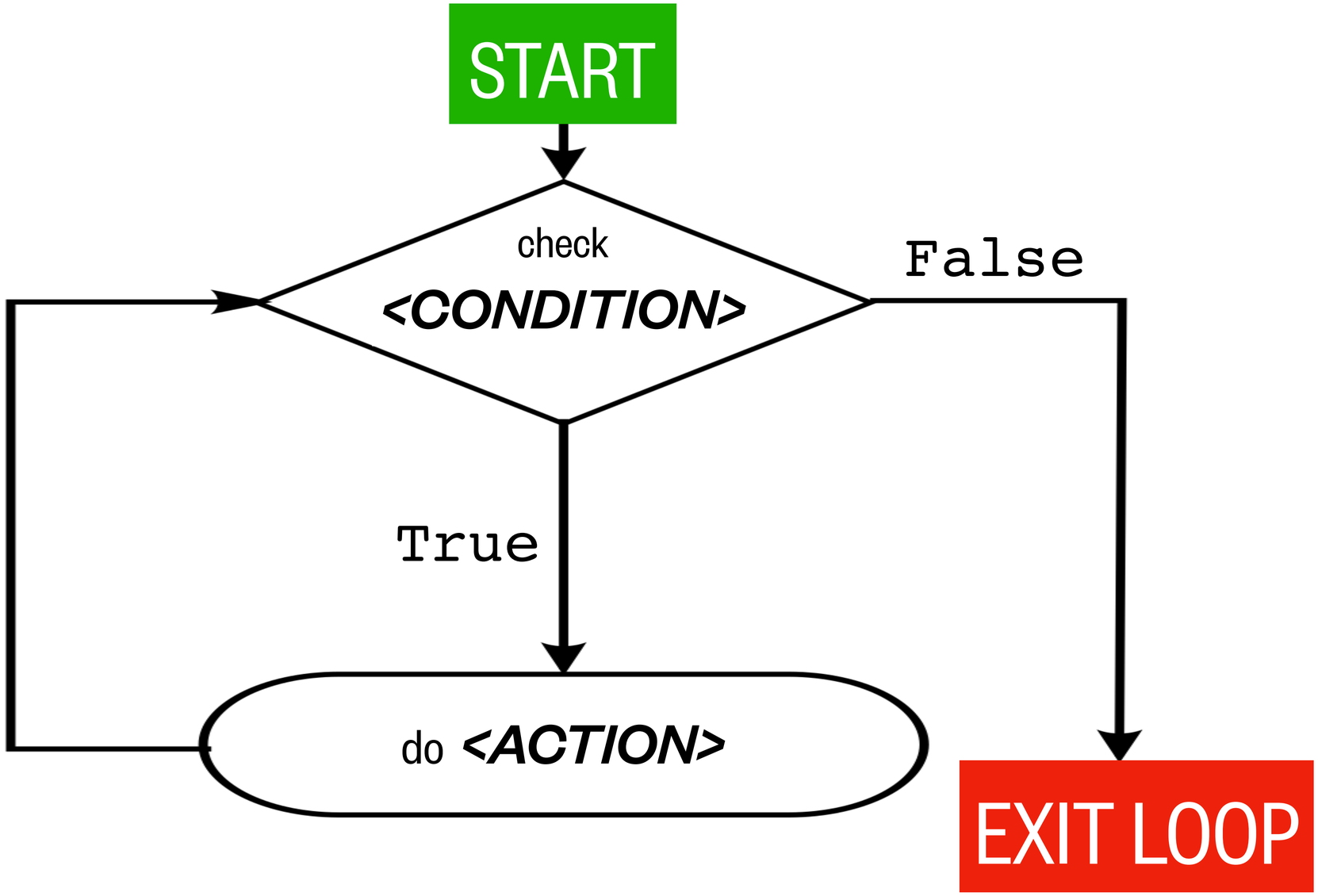
1. `For` loops
2. Advanced `for` loops
3. **`While` loops and list comprehensions**
4. `If` statements

Elements of the Python `while` loop

```
while <BOOLEAN CONDITION>:
    <ACTION>
    <ACTION>
    etc.
```

Control flow of the `while` loop

```
while <CONDITION>:
    <ACTION>
    <ACTION>
    etc.
```



The infinite loop

```
while True:
    <ACTION>
```

A useful `while` loop

Print all of the powers of 2 (2^0, 2^1, 2^2, 2^3, etc.) that are less than 1000:

```
base = 2
exponent = 0
result = base**exponent

while result < 1000:
  print(result)
  exponent += 1
  result = base**exponent
```

```
1
2
4
8
16
32
64
128
256
512
```

An alternative to loops: list comprehensions

Create a list containing the first ten perfect squares (0^2, 1^2, 2^2, 3^2, 4^2, etc.):

Option 1 (for loop):

```
squares = []
for num in range(10):
  squares.append(num * num)

print(squares)
```

```
[0, 1, 4, 9, 16, 25, 36, 49, 64, 81]
```

An alternative to loops: list comprehensions

Create a list containing the first ten perfect squares (0^2, 1^2, 2^2, 3^2, 4^2, etc.):

Option 2 (list comprehension):

```
1 squares = [num * num for num in range(10)]
2
3 print(squares)
```

Calculation

This looks like a `for` loop!

```
[0, 1, 4, 9, 16, 25, 36, 49, 64, 81]
```

What we'll cover in this lesson

1. `For` loops
2. Advanced `for` loops
3. `While` loops and list comprehensions
4. **`If` statements**

Elements of the Python `if` statement

```
if <CONDITION>:
    <ACTION>
    <ACTION>
    etc.
```

Review of Boolean operators

Comparison	`==, !=, >, >=, <, <=`
Logical	`and, or, not`
Membership	`in, not in`
Identity	`is, is not`

Examples of `if` statements

```
x = 5

if x > 0:
  print('x is positive!')
```

```
x is positive!
```

Examples of `if` statements

```
x = -3

if x > 0:
  print('x is positive!')
```

`if/elif` statements

```
if <CONDITION #1>:
    <ACTION #1>
elif <CONDITION #2>:
    <ACTION #2>
```

Note:
`elif` stands for "else if"

`if/elif` statements

```
if <CONDITION #1>:
    <ACTION #1>
elif <CONDITION #2>:
    <ACTION #2>
elif <CONDITION #3>:
    <ACTION #3>
```

`if/elif/else` statements

```
if <CONDITION #1>:
    <ACTION #1>
elif <CONDITION #2>:
    <ACTION #2>
elif <CONDITION #3>:
    <ACTION #3>
else:
    <ACTION #4>
```

`if/elif/else` statements

```
likelihood_precip = 80   # i.e. 80% chance of rain

if likelihood_precip > 50:
  print('Ugh... I better wear a rain jacket.')
elif likelihood_precip < 20:
  print("I'll be okay without a rain jacket.")
else:
  print("I don't know what to do.")
```

```
Ugh... I better wear a rain jacket.
```

`if/elif/else` statements

```
likelihood_precip = 5   # i.e. 5% chance of rain

if likelihood_precip > 50:
  print('Ugh... I better wear a rain jacket.')
elif likelihood_precip < 20:
  print("I'll be okay without a rain jacket.")
else:
  print("I don't know what to do.")
```

```
I'll be okay without a rain jacket.
```

`if/elif/else` statements

```
likelihood_precip = 30   # i.e. 30% chance of rain

if likelihood_precip > 50:
  print('Ugh... I better wear a rain jacket.')
elif likelihood_precip < 20:
  print("I'll be okay without a rain jacket.")
else:
  print("I don't know what to do.")
```

```
I don't know what to do.
```