***The cell above loads the visual style of the notebook when run.***

In [1]:
```
from IPython.core.display import HTML
css_file = '../styles.css'
HTML(open(css_file, "r").read())
```

Out[1]:

# Repeating actions with loops

## Learning Objectives

- Explain what a `for` loop does

- Correctly write loops to repeat simple calculations
- Trace changes to variables as the loop runs

In the last lesson we wrote some code that plots the brightness of stars from our first dataset. However, we have a dozen different data sets and more on the way. We want to create plots for all our data sets with a single statement. To do that, we'll have to teach the computer how to repeat things.

An example task that we might want to repeat is printing each character in a word on a line of its own. One way to do this would be to use a series of `print` statements:

In [2]:
```
word = 'lead'
print (word[0])
print (word[1])
print (word[2])
print (word[3])
```

```
l
e
a
d
```

but that's a bad approach for two reasons:

1. **It doesn't scale:** if we want to print the characters in a string that's hundreds of letters long, we'd be better off just typing them in.
2. **It's fragile:** if we give it a longer string, it only prints part of the data, and if we give it a shorter one, it produces an error because we're asking for characters that don't exist.

In [3]:
```
word = 'tin'
print (word[0])
print (word[1])
print (word[2])
print (word[3])
```

```
t
i
n

---------------------------------------------------------------------------
IndexError                                Traceback (most recent call last)
<ipython-input-3-72276b558f93> in <module>()
      3 print (word[1])
      4 print (word[2])
----> 5 print (word[3])

IndexError: string index out of range
```

Here's a better approach:

In [4]:
```
word = 'banana'
for letter in word:
    print (letter)
```

```
b
a
n
a
n
a
```

This is shorter - certainly shorter than something that prints every character in a hundred-letter string - and more robust as well:

In [5]:
```
word = 'fish'
for letter in word:
    print (letter)
```

```
f
i
s
h
```

The improved version of `print_characters` uses a for loop (reference.html#for-loop) to repeat an operation - in this case, printing - once for each thing in a collection. The general form of a loop is:

```
for variable in collection:
    do things with variable
```

We can call the loop variable (reference.html#loop-variable) anything we like ( `variable` in the example above), but there must be a colon at the end of the line starting the loop, and we must indent anything we want to run inside the loop. Unlike many other languages, there is no command to end a loop (e.g. `end for` ); what is *indented* after the `for` statement belongs to the loop.

Here's another loop that repeatedly updates a variable:

In [6]:
```
length = 0
for vowel in 'aeiou':
    length = length + 1
print ('There are', length, 'vowels')
```

```
There are 5 vowels
```

It's worth tracing the execution of this little program step by step. Since there are five characters in `'aeiou'` , the statement on line 3 will be executed five times. The first time around, `length` is zero (the value assigned to it on line 1) and `vowel` is `'a'` .

The statement adds 1 to the old value of `length` , producing 1, and updates `length` to refer to that new value. The next time around, `vowel` is `'e'` and `length` is 1, so `length` is updated to be 2. After three more updates, `length` is 5; since there is nothing left in `'aeiou'` for Python to process, the loop finishes and the `print` statement on line 4 tells us our final answer.

Note that a loop variable is just a variable that's being used to record progress in a loop. It still exists after the loop is over, and we can re-use variables previously defined as loop variables as well:

In [7]:
```
letter = 'z'
for letter in 'abc':
    print(letter)
print('after the loop, letter is', letter)
```

```
a
b
c
after the loop, letter is c
```

Note also that finding the length of a string is such a common operation that Python actually has a built-in function to do it called `len` :

In [8]:
```
print( len('aeiou') )
```

```
5
```

`len` is much faster than any function we could write ourselves, and much easier to read than a two-line loop; it will also give us the length of many other things that we haven't met yet, so we should always use it when we can.

## From 1 to N

> Python has a built-in function called `range` that creates a list of numbers. Range can accept 1-3 parameters. If one parameter is input, range creates an array of that length, starting at zero and incrementing by 1.

> If 2 parameters are input, range starts at the first and ends at the second, incrementing by one. If range is passed 3 parameters, it stars at the first one, ends at the second one, and increments by the third one.

> For example:

> `range(3)` produces `[0, 1, 2]`,

> `range(2, 5)` produces `[2, 3, 4]`.

> `range(2, 10, 2)` produces `[2, 4, 6, 8]`.

> Using `range`, write a loop that uses `range` to print the first 3 natural numbers:

> 1
> 2
> 3

In [11]:
```
# INSERT YOUR CODE HERE

for i in range(1,4):
    print(i)
```

```
1
2
3
```

## ✏Computing powers with loops

Exponentiation is built into Python:

```
print 5 ** 3
125
```

Write a loop that calculates the same result as `5 ** 3` using multiplication (and without exponentiation).

In [27]:
```
# INSERT YOUR CODE HERE

exp = 1

for i in range(1,4):
    exp = exp*5

print(exp)
```

```
125
```

## Reverse a string

Write a loop that takes a string, and produces a new string with the characters in reverse order, so `'Newton'` becomes `'notweN'`.

In [87]:
```
# INSERT YOUR CODE HERE

print(list(range(10,1,-1)))

print(list(range(10))[::-1])

for i in range(10):
    print(10-i)

letter = 'z'
the_letters = ''
for letter in 'abc':
    the_letters = the_letters + letter

print(the_letters)

answer = ''
for letter in 'word':
    answer = answer + letter
print(answer)


word = 'Newton'
for i in range(len(word)):
    print(word[len(word)-1-i])
    print(word[-(i+1)])
```

```
[10, 9, 8, 7, 6, 5, 4, 3, 2]
[9, 8, 7, 6, 5, 4, 3, 2, 1, 0]
10
9
8
7
6
5
4
3
2
1
abc
word
n
n
o
o
t
t
w
w
e
e
N
N
```

In [107]:
```
word = 'Newton'
back = ''
for i in range(len(word)):
    #print(word[len(word)-1-i])
    name = word[-(i+1)]
    back = back + name

print(back)
```

```
notweN
```

In [ ]:
```

```