

## Functional Ideas in Python

“Gematria” is a system for assigning a number to a word by summing the numeric values of each of the letters as defined by the Mispar godol (<https://en.wikipedia.org/wiki/Gematria>). For English characters, we can use the ASCII table (<https://en.wikipedia.org/wiki/ASCII>). It is not necessary, however, to encode this table in our program as Python provides the `ord` function to convert a character to its “ordinal” (order in the ASCII table) value as well as the `chr` function to convert a number to its “character.”

```
print("{}" = "{}".format('A', ord('A')))  
"A" = "65"  
  
print("{}" = "{}".format('a', ord('a')))  
"a" = "97"  
  
print("{}" = "{}".format(88, chr(88)))  
"88" = "X"  
  
print("{}" = "{}".format(112, chr(112)))  
"112" = "p"
```

To implement an ASCII version of gematria in Python, we need to turn each letter into a number and add them all together. So, to start, note that Python can use a `for` loop to cycle through all the members of a list (in order):

```
for n in range(5):  
    print(n)  
  
0  
1  
2  
3  
4  
  
for char in ['p', 'y', 't', 'h', 'o', 'n']:  
    print(char)  
  
p  
y  
t  
h  
o  
n
```

A “word” is simply a list of characters, so we can iterate over it just like a list of numbers:

```
for char in "python":
    print(char)
```

```
p
y
t
h
o
n
```

Let's print the ordinal (ASCII) value instead:

```
for char in "python":
    print("{}" = "{}".format(char, ord(char)))
```

```
"p" = "112"
"y" = "121"
"t" = "116"
"h" = "104"
"o" = "111"
"n" = "110"
```

Now let's create a variable to hold the running sum of the values:

```
word = "python"
total = 0
for char in word:
    total += ord(char)

print("{}" = "{}".format(word, total))

"python" = "674"
```

Another way could be to create another list to hold the values and then use the sum function:

```
word = "python"
all = []
for char in word:
    all.append(ord(char))

print(all)
print("{}" = "{}".format(word, sum(all)))

[112, 121, 116, 104, 111, 110]
"python" = "674"
```

## Map

We can use a `map` function to transform all the characters via the `ord` function. This is interesting because `map` is a function that takes another function as its first argument. The second is a list of items to feed into the function. The result is the transformed list. For instance, we can use the `str.upper` function to turn each letter (e.g., “p”) into the upper-case version (“P”). NB: it’s necessary to force the results into a `list`.

```
list(map(str.upper, "python"))
['P', 'Y', 'T', 'H', 'O', 'N']
list(map(ord, "python"))
[112, 121, 116, 104, 111, 110]
```

Now we can `sum` those numbers:

```
sum(map(ord, "python"))
674
```

Now let’s think about how we could apply this to all the words in a file. As above, we can use a `for` loop to iterate over all the lines in a file:

```
for line in open('gettysburg.txt'):
    print(line)
```

```
Four score and seven years ago our fathers brought forth on this
continent, a new nation, conceived in Liberty, and dedicated to the
proposition that all men are created equal.
```

The original is single-spaced, so why is this printing double-spaced? The `for` loop reads each “line” which is a string of text up to and including a newline. The `print` by default adds a newline, so we either need to `print(line, end='')` to indicate we don’t want anything at the end:

```
for line in open('gettysburg.txt'):
    print(line, end='')
```

```
Four score and seven years ago our fathers brought forth on this
continent, a new nation, conceived in Liberty, and dedicated to the
proposition that all men are created equal.
```

Or we need to use the `rstrip` function to “strip” whitespace off the “r”ight side of the line:

```
for line in open('gettysburg.txt'):
    print(line.rstrip())
```

Four score and seven years ago our fathers brought forth on this continent, a new nation, conceived in Liberty, and dedicated to the proposition that all men are created equal.

We can use the `split` function to get all the words for each line and a `for` loop to iterate over those:

```
for line in open('gettysburg.txt'):
    for word in line.rstrip().split():
        print(word)
```

```
Four
score
and
seven
years
ago
our
fathers
brought
forth
on
this
continent,
a
new
nation,
conceived
in
Liberty,
and
dedicated
to
the
proposition
that
all
men
are
created
equal.
```

We want to get rid of anything that is not character like the punctuation. There is a function in the `str` library called `isalpha` that returns `True` or `False`:

```
for char in "a8,X.b!G":
    print("{}" = "{}".format(char, str.isalpha(char)))

"a" = "True"
```

```

"8" = "False"
", " = "False"
"X" = "True"
"." = "False"
"b" = "True"
"!" = "False"
"G" = "True"

```

Each `char` in the loop is itself a string, so we can call the method directly on the variable:

```

for char in "a8,X.b!G":
    print("{}" = "{}".format(char, char.isalpha()))

"a" = "True"
"8" = "False"
", " = "False"
"X" = "True"
"." = "False"
"b" = "True"
"!" = "False"
"G" = "True"

```

## Filter

Similar to what we saw above with the `map` function, we can use `filter` to find all the characters in a string which are `True` for `isalpha`. `filter` is another “higher-order function” that takes another function for its first argument (called the “predicate”) and a list as the second argument. Whereas `map` returns *all* the elements of the list transformed by the function, `filter` returns *only those for which the predicate is true*.

```

list(filter(str.isalpha, "a8,X.b!G"))

['a', 'X', 'b', 'G']

```

The first argument for `map` and `filter` is called the “lambda,” and sometimes you will see it written out explicitly like so:

```

list(filter(lambda char: char.isalpha(), "a8,X.b!G"))

['a', 'X', 'b', 'G']

```

Here is a way to find only even numbers:

```

list(filter(lambda x: x % 2 == 0, range(10)))

[0, 2, 4, 6, 8]

```

Let’s turn that list of characters back into a word with the `join` function:

```
' '.join(filter(str.isalpha, "a8,X.b!G"))
'aXbG'
```

## Aside (Regular expressions)

**NB:** This is not the way I would actually remove punctuation in my own code. I'd be more likely to use regular expressions, e.g., “anything not A-Z, a-z, and 0-9”:

```
import re
print(re.sub('[^A-Za-z0-9]', ' ', 'a8,X.b!G'))
a8XbG
```

The `string` class actually defines “punctuation”:

```
import string
print(string.punctuation)
!"#$%&'()*+,-./:;<=>?@[\\]^_`{|}~
```

So we could use that to create a character class of punctuation if that was the only thing we intended to remove:

```
import string
print(re.sub('[ ' + string.punctuation + ']', ' ', 'a8,X.b!G'))
a8XbG
```

## Combining map and filter

So, going back to our Gettysburg example, here is a list of all the words without punctuation:

```
for line in open('gettysburg.txt'):
    for word in line.rstrip().split():
        print(' '.join(filter(str.isalpha, word)))
```

```
Four
score
and
seven
years
ago
our
fathers
brought
```

forth  
on  
this  
continent  
a  
new  
nation  
conceived  
in  
Liberty  
and  
dedicated  
to  
the  
proposition  
that  
all  
men  
are  
created  
equal

Now, rather let's print the sum of the chr values for each cleaned up word:

```
for line in open('gettysburg.txt'):
    for word in line.rstrip().split():
        clean = ''.join(filter(str.isalpha, word))
        print("{}" = "{}".format(clean, sum(map(ord, clean))))
```

"Four" = "412"  
"score" = "540"  
"and" = "307"  
"seven" = "545"  
"years" = "548"  
"ago" = "311"  
"our" = "342"  
"fathers" = "749"  
"brought" = "763"  
"forth" = "547"  
"on" = "221"  
"this" = "440"  
"continent" = "978"  
"a" = "97"  
"new" = "330"  
"nation" = "649"  
"conceived" = "944"  
"in" = "215"

```

"Liberty" = "731"
"and" = "307"
"dedicated" = "919"
"to" = "227"
"the" = "321"
"proposition" = "1222"
"that" = "433"
"all" = "313"
"men" = "320"
"are" = "312"
"created" = "728"
"equal" = "536"

```

Notice that we are calling `rstrip` for every line, so we could easily move that into a `map`, and the “cleaning” code can likewise be moved into a `map`:

```

for line in map(str.rstrip, open('gettysburg.txt')):
    for word in map(lambda w: ''.join(filter(str.isalpha, w)), line.split()):
        print("{} = {}".format(word, sum(map(ord, word))))

```

```

"Four" = "412"
"score" = "540"
"and" = "307"
"seven" = "545"
"years" = "548"
"ago" = "311"
"our" = "342"
"fathers" = "749"
"brought" = "763"
"forth" = "547"
"on" = "221"
"this" = "440"
"continent" = "978"
"a" = "97"
"new" = "330"
"nation" = "649"
"conceived" = "944"
"in" = "215"
"Liberty" = "731"
"and" = "307"
"dedicated" = "919"
"to" = "227"
"the" = "321"
"proposition" = "1222"
"that" = "433"
"all" = "313"
"men" = "320"

```



```
"are" = "312"  
"created" = "728"  
"equal" = "536"
```

At this point, we have arguably sacrificed readability for the sake of using `map` and `filter` – another instance of “just because you can doesn’t mean you should!”

We can improve readability, however, by creating our own functions with informative names. Also, since `onlychars` will get rid of the trailing newlines, we can remove the `line.rstrip()` call:

```
def onlychars(word):  
    return ''.join(filter(str.isalpha, word))  
  
def word2num(word):  
    return sum(map(ord, word))  
  
for line in open('gettysburg.txt'):  
    for word in map(onlychars, line.split()):  
        print("{} = {}".format(word, word2num(word)))  
  
"Four" = "412"  
"score" = "540"  
"and" = "307"  
"seven" = "545"  
"years" = "548"  
"ago" = "311"  
"our" = "342"  
"fathers" = "749"  
"brought" = "763"  
"forth" = "547"  
"on" = "221"  
"this" = "440"  
"continent" = "978"  
"a" = "97"  
"new" = "330"  
"nation" = "649"  
"conceived" = "944"  
"in" = "215"  
"Liberty" = "731"  
"and" = "307"  
"dedicated" = "919"  
"to" = "227"  
"the" = "321"  
"proposition" = "1222"  
"that" = "433"  
"all" = "313"  
"men" = "320"
```

```
"are" = "312"
"created" = "728"
"equal" = "536"
```

## Golfing

“Golfing” in code is when you try to express your code in fewer and fewer keystrokes. At some point you cross the line of cleanliness to absurdity. Remember:

It’s such a fine line between stupid and clever. – David St. Hubbins  
(<https://www.youtube.com/watch?v=wtXkD1BC564>)

Here’s a streamlined version that combines `open`, `read`, and `split` to read the entire file into a list of words which are `mapd` into `word2num`.

**NB:** This version assumes you have enough memory to read an *entire file* and split it. The versions above which read and process each line consume only as much memory as any one line needs!

```
def onlychars(word):
    return ''.join(filter(str.isalpha, word))

def word2num(word):
    return str(sum(map(ord, word)))

print(' '.join(map(word2num,
                    map(onlychars,
                        open('gettysburg.txt').read().split()))))
```

412 540 307 545 548 311 342 749 763 547 221 440 978 97 330 649 944 215 731 307 919 227 321 1

To mimic the above output:

```
def onlychars(word):
    return ''.join(filter(str.isalpha, word))

def word2num(word):
    return str(sum(map(ord, onlychars(word))))

print('\n'.join(map(lambda word: "{}" = "{}".format(word, word2num(word)),
                    map(onlychars,
                        open('gettysburg.txt').read().split()))))

"Four" = "412"
"score" = "540"
"and" = "307"
"seven" = "545"
"years" = "548"
```

```

"ago" = "311"
"our" = "342"
"fathers" = "749"
"brought" = "763"
"forth" = "547"
"on" = "221"
"this" = "440"
"continent" = "978"
"a" = "97"
"new" = "330"
"nation" = "649"
"conceived" = "944"
"in" = "215"
"Liberty" = "731"
"and" = "307"
"dedicated" = "919"
"to" = "227"
"the" = "321"
"proposition" = "1222"
"that" = "433"
"all" = "313"
"men" = "320"
"are" = "312"
"created" = "728"
"equal" = "536"

```

With this, I hope you're now understand what is meant by a “higher-order function” (functions that take other functions as arguments) and how they can streamline your code.

## Exercise

Read your local dictionary (e.g., “/usr/share/dict/words”) and find how many words share the same numeric representation. Which ones have the value “666”?

```

from collections import defaultdict

def onlychars(word):
    return ''.join(filter(str.isalpha, word))

file = '/usr/share/dict/words'
num2word = defaultdict(list)
for line in map(str.rstrip, open(file)):
    for word in map(onlychars, line.split()):
        num = sum(map(ord, word))
        num2word[num].append(word)

```

```

satan = '666'
if satan in num2word:
    print('Satan =', num2word[satan])
else:
    print('No Satan!')

count_per_n = []
for n, wordlist in num2word.items():
    count_per_n.append((len(wordlist), n))

top10 = list(reversed(sorted(count_per_n))[:10])
for num_of_words, n in top10:
    print('{} ({} words) = {} ...'.format(n, len(num2word[n]), ', '.join(num2word[n][:3])))

No Satan!
973 (623 words) = Actaeaceae, activator, actorship ...
969 (621 words) = abrotanum, acclivous, acidulous ...
965 (611 words) = abhorrent, acoumeter, acronymic ...
855 (607 words) = abuseful, acanthus, acronych ...
861 (601 words) = Absyrtus, acaulous, adjuvant ...
856 (597 words) = abrastol, accismus, acervose ...
971 (596 words) = aburabozu, acropathy, acuteness ...
974 (594 words) = ablastous, absolvent, abysmally ...
972 (592 words) = accessory, acropolis, acutiator ...
1078 (587 words) = absentness, acrogenous, actinozoan ...

```