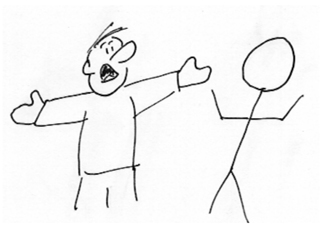
1. Password Strength: Generating a secure and memorable password



It’s not easy to create passwords that are both difficult to guess and easy to remember. An an XKCD comic (https://xkcd.com/936/) describes an algorithm that provides both security and recall by suggesting that a password be composed of "four random common words." For instance, the comic suggests that the password composed of the words "correct," "horse," "battery," and "staple" would provide "~44 bits of entropy" which would require around 550 years for a computer to guess given 1,000 guess per second.

We’re going to write a program called `password.py` that will create passwords by randomly combining the words from some input files. Many computers have a file that lists thousands of English words each on a separate line. On most of my systems, I can find this at `/usr/share/dict/words`, and it contains over 235,000 words! As the file can vary by system, I’ve added a version the repo so that we can use the same file. This file is a little large, so I’ve compressed to `inputs/words.txt.zip`. You should unzip it before using it:

```
$ unzip inputs/words.txt.zip
```

Now we should both have the same `inputs/words.txt` file so that this is reproducible for you:

```
$ ./password.py ../inputs/words.txt --seed 14
CrotalLeavesMeeredLogy
NatalBurrelTizzyOddman
UnbornSignerShodDehort
```

Hmm, maybe those aren’t going to be the easiest to remember! Perhaps instead we should be a bit more judicious about the source of our words? We’re drawing from a pool of over 200K words, but the average speaker tends to use somewhere between 20,000 and 40,000 words.

We can generate more memorable passwords by drawing from some actual piece of English text such as the US Constitution. Note that to use a piece of input text in this way, we will need to remove any punctuation as we have done in previous exercises:

```
$ ./password.py --seed 8 ../inputs/const.txt
DulyHasHeadsCases
DebtSevenAnswerBest
ChosenEmitTitleMost
```

Another strategy for generating memorable words could be to limit the pool of words to more interesting parts of speech like nouns, verbs, and adjectives taken from texts like novels or poetry.

I've included a program I wrote called `harvest.py` that uses a Natural Language Processing library in Python called "spaCy" (https://spacy.io) that will extract those parts of speech into files that we can use as input to our program. If you want to use this program on your own input files, you'll need to be sure to first install the module:

```
$ python3 -m pip install spacy
```

I ran the `harvest.py` program on some texts and placed the outputs into directories in the source repo. For instance, here is the output drawing from nouns found in the US Constitution:

```
$ ./password.py --seed 5 const/nouns.txt
TaxFourthYearList
TrialYearThingPerson
AidOrdainFifthThing
```

And here we have passwords generated using only verbs found in *The Scarlet Letter* by Nathaniel Hawthorne:

```
$ ./password.py --seed 1 scarlet/verbs.txt
CrySpeakBringHold
CouldSeeReplyRun
WearMeanGazeCast
```

And here are some generated from adjectives extracted from William Shakespeare's sonnets:

```
$ ./password.py --seed 2 sonnets/adjs.txt
BoldCostlyColdPale
FineMaskedKeenGreen
BarrenWiltFemaleSeldom
```

Just in case that is not a strong enough password, we will also provide a `--l33t` flag to further obfuscate the text by:

1. Passing the generated password through the `ransom.py` algorithm from Chapter 12
2. Substituting various characters with given table as we did in `jump_the_five.py` from Chapter 4
3. Adding a randomly selected punctuation character to the end

Here is what the Shakespearean passwords look like with this encoding:

```
$ ./password.py --seed 2 sonnets/adjs.txt --l33t
B0LDco5TLYColdp@l3,
f1n3M45K3dK3eNGR33N[
B4rReNW1LTFeM4l3seldoM/
```

In this exercise, you will:

- Take an optional list of input files as positional arguments.
- Use a regular expression to remove non-word characters.
- Filter words by some minimum length requirement.
- Use sets to create unique lists.
- Generate some given number of passwords by combining some given number of randomly selected words.
- Optionally encode text using a combination of algorithms we've previously written.

1.1. Writing `password.py`

Our program will be called `password.py` and will create some `--num` number of passwords (default `3`) each created by randomly choosing some `--num_words` (default `4`) from a unique set of words from one or more input files. As it will use the `random` module, the program will also accept a random `--seed` argument. The words from the input files will need to be a minimum length of some `--min_word_len` (default `3`) up to a `--max_word_len` (default `6`) after removing any non-characters.

As always, your first priority is to sort out the inputs to your program. Do not move ahead until your program can produce this usage with the `-h` or `--help` flags and can pass the first 8 tests:

```
$ ./password.py -h
usage: password.py [-h] [-n num_passwords] [-w num_words] [-m mininum]
                   [-x maximumm] [-s seed] [-l]
                   FILE [FILE ...]

Password maker

positional arguments:
  FILE                  Input file(s)

optional arguments:
  -h, --help            show this help message and exit
  -n num_passwords, --num num_passwords
                        Number of passwords to generate (default: 3)
  -w num_words, --num_words num_words
                        Number of words to use for password (default: 4)
  -m mininum, --min_word_len mininum
                        Minimum word length (default: 3)
  -x maximumm, --max_word_len maximumm
                        Maximum word length (default: 6)
  -s seed, --seed seed  Random seed (default: None)
  -l, --l33t            Obfuscate letters (default: False)
```

The words from the input files will be title-cased (first letter uppercase, the rest lowercased) which we can achieve using the `str.title()` method. This makes it easier to see and remember the individual words in the output. Note that we can vary the number of words included in each password as well as the number of passwords generated:

```
$ ./password.py --num 2 --num_words 3 --seed 9 sonnets/*
QueenThenceMasked
GullDeemdEven
```

The `--min_word_len` argument helps to filter out shorter, less interesting words like "a", "I," "an," "of," etc., while the `--max_word_len` prevents the passwords from becoming unbearably long. If you increase these values, then the passwords change quite drastically:

```
$ ./password.py -n 2 -w 3 -s 9 -m 10 -x 20 sonnets/*
PerspectiveSuccessionIntelligence
DistillationConscienceCountenance
```

The `--l33t` flag is a nod to "leet"-speak where `31337 H4X0R` means "ELITE HACKER" [1]. When this flag is present, we'll encode each of the passwords, first by passing the word through the `ransom()` algorithm we wrote:

```
$ ./ransom.py MessengerRevolutionImportune
MesSENGeRReVolUtIonImpoRtune
```

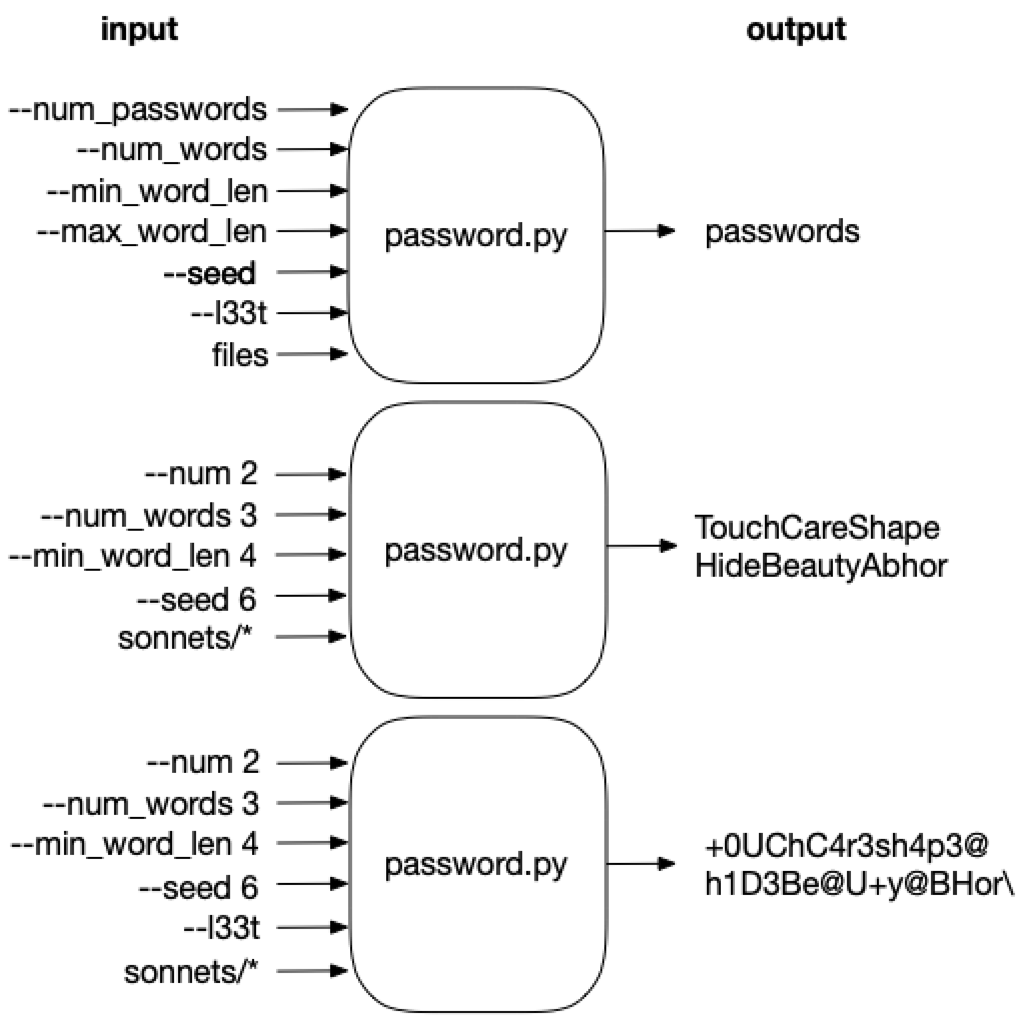
Then we'll use the following substitution table to substitute characters in the same way we did in "Jump the Five":

```
 a => @
 A => 4
 O => 0
 t => +
 E => 3
 I => 1
 S => 5
```

To cap it off, we'll use `random.choice()` to select one character from `string.punctuation` to add to the end:

```
$ ./password.py --num 2 --num_words 3 --seed 9 --min_word_len 10 --max_word_len 20
sonnets/* --l33t
p3RsPeC+1Vesucces5i0niN+3lL1Genc3$
D1s+iLl@+ioNconsc1eNc3coun+eN@Nce^
```

Here is the string diagram to summarize the inputs:



1.1.1. Creating a unique list of words

Let's start off by making our program print the name of each input file:

```
def main():
    args = get_args()
    random.seed(args.seed) ①

    for fh in args.file:   ②
        print(fh.name)     ③
```

① Always set `random.seed()` right away as it will globally affect all actions by the `random` module.

② Iterate through the file arguments.

③ Print the name of the file.

Let's test it with the `words.txt` file:

```
$ ./password.py ../inputs/words.txt
../inputs/words.txt
```

Or with some of the other inputs:

```
$ ./password.py scarlet/*
scarlet/adjs.txt
scarlet/nouns.txt
scarlet/verbs.txt
```

Our first goal is to create a unique list of words we can use for sampling. So far we've used lists to keep ordered collections and dictionaries to create key/value structures. The elements in a `list` do not have to be unique, so we can't use that. The keys of a dictionary *are* unique, however, so that's a possibility:

```
def main():
    args = get_args()
    random.seed(args.seed)
    words = {}            ①

    for fh in args.file: ②
        for line in fh:  ③
            for word in line.lower().split(): ④
                words[word] = 1               ⑤

    print(words)
```

① Create an empty `dict` to hold the words.

② Iterate through the files.

③ Iterate through the lines of the file.

④ Lowercase the line and split it on spaces into words.

⑤ Set the key `words[word]` equal to `1` to indicate we saw it. We're only using a `dict` to get the unique keys. We don't care about the values, so you could use whatever value you like.

If you run this on the US Constitution, you should should see a fairly large list of words (some output elided here):

```
$ ./password.py ../inputs/const.txt
{'we': 1, 'the': 1, 'people': 1, 'of': 1, 'united': 1, 'states,': 1, ...}
```

I can spot one problem in that the word `'states,'` has a comma attached to it. If we try in the REPL with the first bit of text from the Constitution, we can see the problem:

```
>>> 'We the People of the United States,'.lower().split()
['we', 'the', 'people', 'of', 'the', 'united', 'states,']
```

How can we get rid of punctuation?

1.1.2. Cleaning the text

We’ve seen several times that splitting on spaces leaves punctuation, but splitting on non-word characters can break contracted words like "Don’t" in two. I’d like to create a function that will `clean()` a word. First I’ll imagine the test for it. Note that in this exercise, I’ll put all my unit tests into a file called `unit.py` which I can run with `pytest -xv unit.py`.

Here is the test for our `clean()` function:

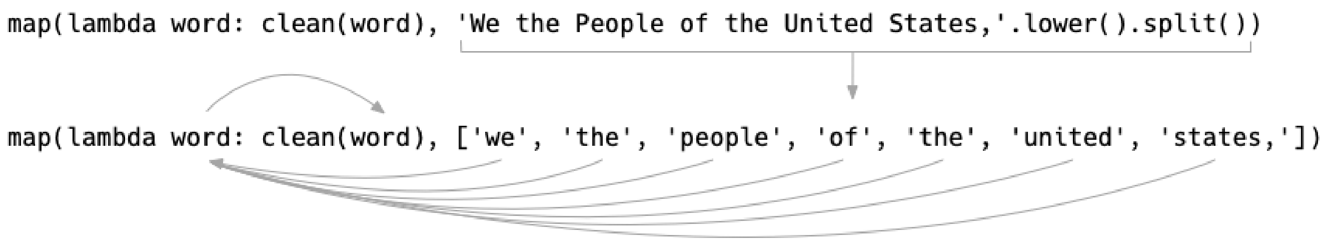
```python
def test_clean():
    assert clean('') == ''                  ①
    assert clean("states,") == 'states' ②
    assert clean("Don't") == 'Dont'     ③
```

① It’s always good to test your functions on nothing just to make sure it does something sane.

② The function should remove punctuation at the end of a string.

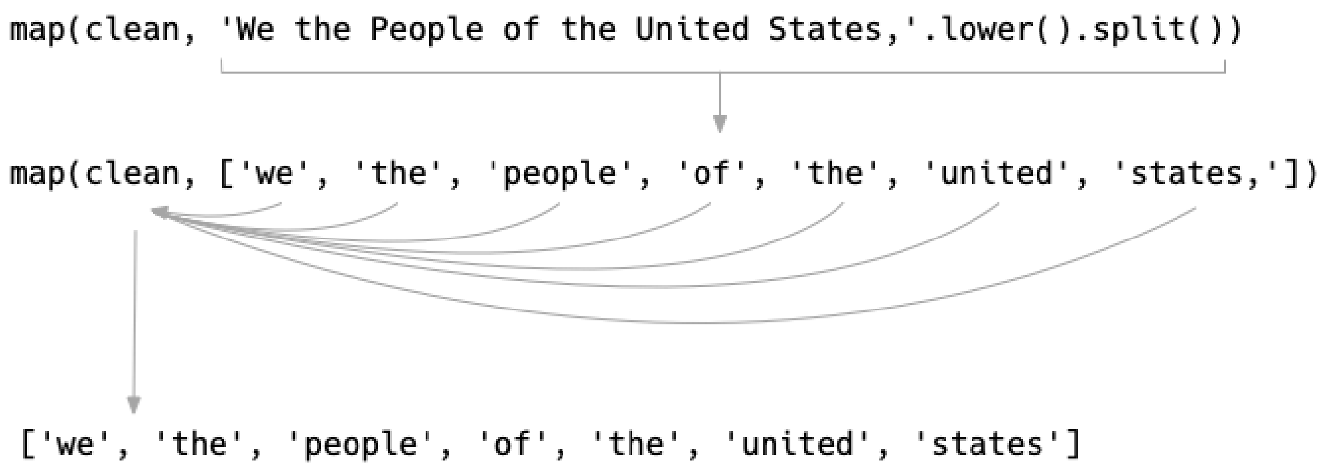
③ The function should not split a contracted word in two.

I would like to apply this to all the elements returned by splitting each line into words, and `map()` is a fine way to do that. We often use a `lambda` when writing `map()`:



```
map(lambda word: clean(word), 'We the People of the United States,'.lower().split())

map(lambda word: clean(word), ['we', 'the', 'people', 'of', 'the', 'united', 'states,'])
```

Notice that I do not need to write a `lambda` for the `map()` because the `clean()` function expects a single argument:



```
map(clean, 'We the People of the United States,'.lower().split())

map(clean, ['we', 'the', 'people', 'of', 'the', 'united', 'states,'])

['we', 'the', 'people', 'of', 'the', 'united', 'states']
```

See how it integrates with the code:

```
def main():
    args = get_args()
    random.seed(args.seed)
    words = {}

    for fh in args.file:
        for line in fh:
            for word in map(clean, line.lower().split()): ①
                words[word] = 1

    print(words)
```

① Use `map()` to apply the `clean()` function to the results of splitting the `line` on spaces. No `lambda` is required because `clean()` expects a single argument.

If I run that on the US Constitution again, I see that `'states'` has been fixed:

```
$ ./password.py ../inputs/const.txt
{'we': 1, 'the': 1, 'people': 1, 'of': 1, 'united': 1, 'states': 1, ...}
```

I'll leave it to you to write the `clean()` function that will satisfy that test.

1.1.3. Using a `set`

There is a better data structure than a `dict` to use for our purposes here. It's called a `set`, and you can think of it like a unique `list` or just the keys of a `dict`. Here is how we could change our code to use a `set` to keep track of *unique* words:

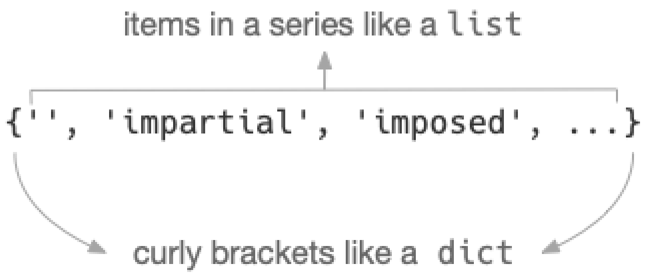
```
def main():
    args = get_args()
    random.seed(args.seed)
    words = set() ①

    for fh in args.file:
        for line in fh:
            for word in map(clean, line.lower().split()):
                words.add(word) ②

    print(words)
```

① Use the `set()` function to create an empty set.

② Use `set.add()` to add a value to a set.

If you run this code now, you will see a slightly different output where Python shows you a data structure in curly brackets (`{}`) that makes you think of a `dict` but you'll notice that the contents look more like a `list`:

```
$ ./password.py ../inputs/const.txt
{'', 'impartial', 'imposed', 'jared', 'levying', ...}
```


items in a series like a list
{'', 'impartial', 'imposed', ...}
curly brackets like a dict

We're using sets here only for the fact that they so easily allow us to keep a unique list of words, but sets are much more powerful than this. For instance, you can find the shared values between two lists by using `set.intersection()`:

```
>>> nums1 = set(range(1, 10))
>>> nums2 = set(range(5, 15))
>>> nums1.intersection(nums2)
{5, 6, 7, 8, 9}
```

You can read `help(set)` in the REPL or the documentation online to learn about all the amazing things you can do with sets.

1.1.4. Filtering the words

If we look again at the output we have, we'll see that the empty string is the first element:

```
$ ./password.py ../inputs/const.txt
{'', 'impartial', 'imposed', 'jared', 'levying', ...}
```

We need a way to filter out unwanted values like strings that are too short. In the "Rhymer" exercise, we looked at the `filter()` function which is a higher-order function that takes two arguments:

1. A function that accepts one element and returns `True` if the element should be kept or `False` if the element should be excluded.
2. Some "iterable" (like a `list` or `map()`) that produces a sequence of elements to be filtered.

In our case, we want to accept only words that have a length greater or equal to the `--min_word_len` argument and less than or equal to the `--max_word_len`. In the REPL, I can use a `lambda` to create an anonymous function that accepts a `word` and makes these comparisons. The result of that comparison is either `True` or `False`. Only words with a length between 3 and 6 are allowed, so this has the effect of removing short, uninteresting words. Remember that `filter()` is lazy, so I have to coerce it using the `list` function in the REPL to see the output:

```
>>> shorter = ['', 'a', 'an', 'the', 'this']
>>> min_word_len = 3
>>> max_word_len = 6
>>> list(filter(lambda word: min_word_len <= len(word) <= max_word_len, shorter))
['the', 'this']
```

It will also remove longer words:

```
>>> longer = ['that', 'other', 'egalitarian', 'disequilibrium']
>>> list(filter(lambda word: min_word_len <= len(word) <= max_word_len, longer))
['that', 'other']
```

One way we could incorporate the `filter()` is to create a `word_len()` function that encapsulates the above `lambda`. Note that I defined it inside the `main()` in order to create a *closure* because I want to include the values of `args.min_word_len` and `args.max_word_len`:

```
def main():
    args = get_args()
    random.seed(args.seed)
    words = set()

    def word_len(word): ①
        return args.min_word_len <= len(word) <= args.max_word_len

    for fh in args.file:
        for line in fh:
            for word in filter(word_len, map(clean, line.lower().split())): ②
                words.add(word)

    print(words)
```

① This function will return `True` if the length of the given `word` is in the allowed range.

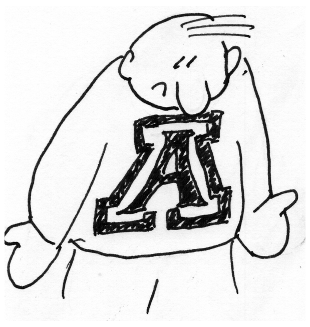
② We can use `word_len` (without the parentheses!) as the function argument to `filter()`.

We can again try our program to see what it produces:

```
$ ./password.py ../inputs/const.txt
{'measures', 'richard', 'deprived', 'equal', ...}
```

Try it on multiple inputs such as all the nouns, adjectives, and verbs from *The Scarlet Letter*:

```
$ ./password.py scarlet/*
{'walk', 'lose', 'could', 'law', ...}
```



1.1.5. Titlecasing the words

We used the `line.lower()` function to lowercase all the input, but the passwords we generate will need each word to be in "Title Case" where the first letter is uppercase and the rest of the word is lower. Can you figure out how to change the program to produce this output?

```
$ ./password.py scarlet/*
{'Dark', 'Sinful', 'Life', 'Native', ...}
```

Now we have a way to process any number of files to produce a unique list of title-cased words that have non-word characters removed and have been filtered to remove the ones that are too short or long. That’s quite a lot of power packed into a few lines of code!

1.1.6. Sampling and making a password

We’re going to use the `random.sample()` function to randomly choose some `--num` number of words from our `set` to create an unbreakable yet memorable password. We’ve talked before about the importance of using a random seed to test that our "random" selections are reproducible. It’s also quite important that the items from which we sample always be ordered in the same way so that the same selections are made. If we use the `sorted()` function on a `set`, we get back a sorted `list` which is perfect for using with `random.sample()`. I can add this line to the code from before:

```python
words = sorted(words)
print(random.sample(words, args.num_words))
```

Now when I run it with *The Scarlet Letter* input, I will get a list of words that might make an interesting password:

```
$ ./password.py scarlet/*
['Lose', 'Figure', 'Heart', 'Bad']
```

The result of `random.sample()` is a `list` that you can join on the empty string in order to make a new password:

```
>>> ''.join(random.sample(words, num_words))
'TokenBeholdMarketBegin'
```

You will need to create `args.num` of passwords. How will you do that?

1.2. l33t-ify

The last piece of our program is to create a `l33t()` function that will obfuscate the password. The first step is to convert it with the same algorithm we wrote for `ransom.py`. I'm going to create a `ransom()` function for this, and here is the test that is in `unit.py`. I'll leave it to you to create the function that satisfies this test [2]:

```
def test_ransom():
    state = random.getstate() ①
    random.seed(1)            ②
    assert (ransom('Money') == 'moNeY')
    assert (ransom('Dollars') == 'DOLlaRs')
    random.setstate(state)    ③
```

① Save the current global state.

② Set the `random.seed()` to a known value for the test.

③ Restore the state.

Next I will substitute some of the characters according to the following table. I would recommend you revisit "Jump The Five" to see how you did that:

```
a => @
A => 4
O => 0
t => +
E => 3
I => 1
S => 5
```

I wrote a `l33t()` function that combines the `ransom()` with the substitution above and finally adds a punctuation character by appending `random.choice(string.punctuation)`. Here is the `test_l33t()` function you can use to write your function. It works almost identically to the above test, so I shall eschew commentary:

```
def test_l33t():
    state = random.getstate()
    random.seed(1)
    assert l33t('Money') == 'moNeY{'
    assert l33t('Dollars') == 'D0ll4r5`'
    random.setstate(state)
```

1.2.1. Putting it all together

Without giving away the ending, I'd like to say that you need to be *really careful* about the order of operations that include the `random` module. My first implementation would print different passwords given the same seed when I used the `--l33t` flag. Here was the output for plain passwords:

```
$ ./password.py -s 1 -w 2 sonnets/*
EagerCarcanet
LilyDial
WantTempest
```

I would have expected the *exact same passwords* only encoded. Here is what my program produced instead:

```
$ ./password.py -s 1 -w 2 sonnets/* --l33t
3@G3RC@rC@N3+{
m4dnes5iNcoN5+4n+|
MouTh45s15T4nCe^
```

The first password looks OK, but what are those other two? I modified my code to print both the original password and the l33ted one:

```
$ ./password.py -s 1 -w 2 sonnets/* --l33t
3@G3RC@rC@N3+{ (EagerCarcanet)
m4dnes5iNcoN5+4n+| (MadnessInconstant)
MouTh45s15T4nCe^ (MouthAssistance)
```

The `random` module uses a global state to make each of its "random" choices. In my first implementation, I was modifying this state after choosing the first password by immediately modifying the new password with the `l33t()` function. Because the `l33t()` function also uses `random` functions, the state was altered for the next password. The solution was to first generate *all* the passwords and then to alter them using the `l33t()` function, if necessary.

Those are all the pieces you should need to write your program. You have the unit tests to help you verify the functions, and you have the integration tests to ensure your program works as a whole.

1.3. Solution

```
#!/usr/bin/env python3
"""Password maker, https://xkcd.com/936/"""

import argparse
import random
import re
import string


# --------------------------------------------------
def get_args():
    """Get command-line arguments"""

    parser = argparse.ArgumentParser(
        description='Password maker',
        formatter_class=argparse.ArgumentDefaultsHelpFormatter)

    parser.add_argument('file',
                        metavar='FILE',
                        type=argparse.FileType('r'),
                        nargs='+',
                        help='Input file(s)')

    parser.add_argument('-n',
                        '--num',
                        metavar='num_passwords',
                        type=int,
                        default=3,
                        help='Number of passwords to generate')

    parser.add_argument('-w',
                        '--num_words',
                        metavar='num_words',
                        type=int,
                        default=4,
                        help='Number of words to use for password')

    parser.add_argument('-m',
                        '--min_word_len',
                        metavar='mininum',
                        type=int,
                        default=3,
                        help='Minimum word length')

    parser.add_argument('-x',
                        '--max_word_len',
                        metavar='maximumm',
                        type=int,
                        default=6,
                        help='Maximum word length')

    parser.add_argument('-s',
                        '--seed',
                        metavar='seed',
                        type=int,
                        help='Random seed')

    parser.add_argument('-l',
                        '--l33t',
                        action='store_true',
                        help='Obfuscate letters')

    return parser.parse_args()


# --------------------------------------------------
def main():
    args = get_args()
    random.seed(args.seed)                                 ①
    words = set()                                          ②

    def word_len(word):                                    ③
        return args.min_word_len <= len(word) <= args.max_word_len

    for fh in args.file:                                   ④
        for line in fh:                                    ⑤
            for word in filter(word_len, map(clean, line.lower().split())): ⑥
                words.add(word.title())                    ⑦

    words = sorted(words)                                  ⑧
    passwords = [                                          ⑨
        ''.join(random.sample(words, args.num_words)) for _ in range(args.num)
    ]

    if args.l33t:                                          ⑩
        passwords = map(l33t, passwords)                   ⑪

    print('\n'.join(passwords))                            ⑫


# --------------------------------------------------
def clean(word):                                           ⑬
    """Remove non-word characters from word"""

    return re.sub('[^a-zA-Z]', '', word)                   ⑭


# --------------------------------------------------
def l33t(text):                                            ⑮
```

```
    """l33t"""

    text = ransom(text)                                    ⑯
    xform = str.maketrans({                                ⑰
        'a': '@', 'A': '4', 'O': '0', 't': '+', 'E': '3', 'I': '1', 'S': '5'
    })
    return text.translate(xform) + random.choice(string.punctuation) ⑱


# --------------------------------------------------
def ransom(text):                                          ⑲
    """Randomly choose an upper or lowercase letter to return"""

    return ''.join(                                        ⑳
        map(lambda c: c.upper() if random.choice([0, 1]) else c.lower(), text))


# --------------------------------------------------
if __name__ == '__main__':
    main()
```

① Set the `random.seed()` to the given value or the default `None` which is the same as not setting the seed.

② Create an empty `set` to hold all the unique of words we'll extract from the texts.

③ Create a `word_len()` function for `filter()` that returns `True` if the word's length is in the allowed range and `False` otherwise.

④ Iterate through each open file handle.

⑤ Iterate through each line of text in the file handle.

⑥ Iterate through each word generated by splitting the lowercased line on spaces, removing non-word characters with the `clean()` function, and filtering for words of an acceptable length.

⑦ Titlecase the word before adding it to the set.

⑧ Use the `sorted()` function to order `words` into a new `list`.

⑨ Use a list comprehension with a `range` to create the correct number of passwords. Since I don't need the actual value from `range`, I can use the `_` to ignore the value.

⑩ See if the `args.l33t` flag is `True`.

⑪ Use `map()` to run all the passwords through the `l33t()` function to produce a new `list` of passwords. It's safe to call the `l33t()` function here. If we had used the function in the list comprehension, it would have altered the global state of the `random` module thereby altering the following passwords.

⑫ Print the passwords joined on newlines.

⑬ Define a function to `clean()` a word.

⑭ Use a regular expression to substitute the empty string for anything that is not an English alphabet character.

⑮ Define a function to `l33t()` a word.

⑯ First use the `ransom()` function to randomly capitalize letters.

⑰ Make a translation table/`dict` for character substitutions.

⑱ Use the `str.translate()` function to perform the substitutions, append a random piece of punctuation.

⑲ Define a function for the `ransom()` algorithm we wrote in chapter 12.

⑳ Return a new string created by randomly upper- or lowercasing each letter in a word.

1.4. Discussion

I hope you found this program challenging and intereting. Let's break it down a bit. There wasn't anything new in `get_args()`, so let's start with the auxiliary functions:

1.4.1. Cleaning the text

I chose to use a regular expression to remove any characters that are outside the set of lowercase and uppercase English characters:

```
def clean(word):
    """Remove non-word characters from word"""
    return re.sub('[^a-zA-Z]', '', word) ①
```

① The `re.sub()` function will substitute any text matching the pattern (the first argument) found in the given text (the third argument) with the value given by the second argument.

Recall from the "Gematria" exercise that we can write the character class `[a-zA-Z]` to define the characters in the ASCII table bounded by those two ranges. We can then *negate* or complement that class by placing a caret `^` as the *first character* inside that class, so `[^a-zA-Z]` can be read as "any character not matching a to z or A to Z."

It's perhaps easier to see it in action in the REPL. In this example, only the letter "AbCd" will be left from the text "A1b*C!d4":

```
>>> import re
>>> re.sub('[^a-zA-Z]', '', 'A1b*C!d4')
'AbCd'
```

If the only goal were to match ASCII letters, it's possible to solve it by looking for membership in `string.ascii_letters`:

```
>>> import string
>>> text = 'A1b*C!d4'
>>> [c for c in text if c in string.ascii_letters]
['A', 'b', 'C', 'd']
```

It honestly seems like more effort to me. Besides, if the function needed to be changed to allow, say, numbers and a few specific pieces of punctuation, then the regular expression version becomes significantly easier to write and maintain.

1.4.2. A king’s ransom

The `ransom()` function was taken straight from the `ransom.py` program, so there isn’t too much to say about it except, hey, look how far we’ve come! What was an entire idea for a chapter is now a single line in a much longer and more complicated program:

```
def ransom(text):
    """Randomly choose an upper or lowercase letter to return"""
    return ''.join( ②
        map(lambda c: c.upper() if random.choice([0, 1]) else c.lower(), text)) ①
```

① Use `map()` iterate through each character in the `text` and select either the upper- or lowercase version of the character based on a "coin" toss using `random.choice()` to select between a "truthy" value (`1`) or a "falsey" value (`0`).

② Join the resulting `list` from the `map()` on the empty string to create a new `str`.

1.4.3. How to `l33t()`

The `l33t()` function builds on the `ransom()` and then adds a text substitution that is straight out of "Jump The Five." I like the `str.translate()` version of that program, so I used it again here:

```
def l33t(text):
    """l33t"""
    text = ransom(text)     ①
    xform = str.maketrans({ ②
        'a': '@', 'A': '4', 'O': '0', 't': '+', 'E': '3', 'I': '1', 'S': '5'
    })
    return text.translate(xform) + random.choice(string.punctuation) ③
```

① First randomly capitalize the given `text`.

② Make a translation table from the given `dict` which describes how to modify one character to another. Any characters not listed in the keys of this `dict` will be ignored.

③ Use the `str.translate()` method to make all the character substitutions. Use `random.choice()` to select one additional character from `string.punctuation` to append to the end.

1.4.4. Processing the files

Now to apply these to the processing of the text. To use these, we need to create a unique set of all the words in our input files. I wrote this bit of code both with an eye on performance and for style:

```
words = set()
for fh in args.file: ①
    for line in fh:  ②
        for word in filter(word_len, map(clean, line.lower().split())): ③
            words.add(word.title()) ④
```

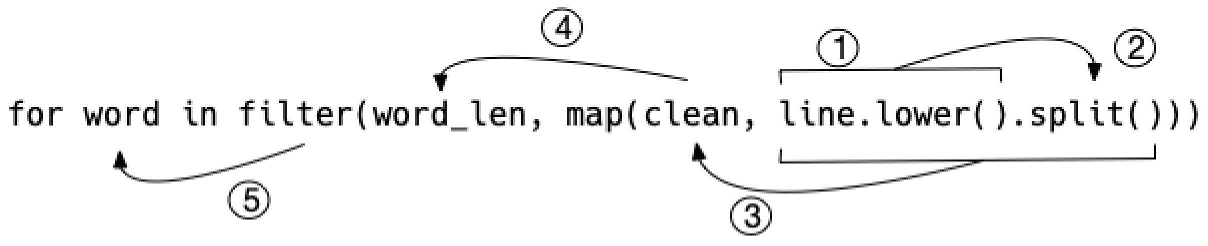
① Iterate through each open file handle.

② Read the file handle line-by-line with a `for` loop, *not* with a method like `fh.read()` which will read the entire contents of the file at once.

③ Reading this code actually requires starting at the end where we split the `line.lower()` on spaces. Each word from `str.split()` goes into `clean()` which then must pass through the `filter()` function.

④ Titlecase the word before adding it to the set.

Here's a diagram of that `for` line:


```
for word in filter(word_len, map(clean, line.lower().split()))
```

1. `line.lower()` will return a lowercase version of `line`.
2. The `str.split()` method will break the text on whitespace to return words.
3. Each word is fed into the `clean()` function to remove any character that is not in the English alphabet.
4. The cleaned words are filtered by the `word_len()` function.
5. The resulting `word` has been transformed, cleaned, and filtered.

If you don't like the `map()` and `filter()` functions, then you might rewrite the code like so:

```
words = set()
for fh in args.file:                           ①
    for line in fh:                            ②
        for word in line.lower().split():      ③
            word = map(clean)                  ④
            if args.min_word_len <= len(word) <= args.max_word_len: ⑤
                words.add(word.title()         ⑥
```

① Iterate through each open file handle.

② Iterate through each line of the file handle.

③ Iterate through each "word" from splitting the lowercased line on spaces.

④ Clean the word up.

⑤ Check if the word is an acceptable length.

⑥ Add the titlecased word to the set.

However you choose to process the files, at this point you should have a complete `set` of all the unique, titlecased words from the input files.

1.4.5. Sampling and creating the passwords

As noted above, it's vital to sort the `words` for our tests so that we can verify that we are making consistent choices. If you only wanted random choices and didn't care about testing, you would not need to worry about sorting—but then you'd also be a morally deficient person for not testing, so perish the thought! I chose to use the `sorted()` function as there is no other way to sort a `set`:

```
words = sorted(words) ①
```

① There is no `set.sort()` function. Sets are ordered internally by Python. Calling `sorted()` on a `set` will create a new, sorted `list`.

We need to create some given number of passwords, and I thought it might be easiest to use a `for` loop with a `range()`. In my code, I used `for _ in range(…)` because I don't need to know the value each time through the loop. The underscore (`_`) is a way to indicate that you are ignoring the value. It's fine to say `for i in range(…)` if you want, but some linters might complain if they see that your code declares the variable `i` but never uses it. That could legitimately be a bug, so it's best to use the `_` to show that you mean to ignore this value.

Here is the first way I wrote the code that led to the bug I mentioned in the discussion where different passwords would be chosen even when I used the same random seed. *Can you spot the bug?*

```
for _ in range(args.num): ①
    password = ''.join(random.sample(words, args.num_words)) ②
    print(l33t(password) if args.l33t else password)         ③
```

① Iterate through the `args.num` of passwords to create.

② Each password will be based on a random sampling from our `words`, and we will choose the value given in `args.num_words`. The `random.sample()` function returns a `list` of words that we `str.join()` on the empty string to create a new string.

③ If the `args.l33t` flag is `True`, then we'll print the l33t version of the password; otherwise, we'll print the password as-is. **This is the bug!** Calling `l33t()` here modifies the global state used by the `random` module, so the next time we call `random.sample()` we get *a different sample*.

The solution is to separate the concerns of *generating* the passwords and possibly modifying them:

```
passwords = [                 ①
    ''.join(random.sample(words, args.num_words)) for _ in range(args.num)
]

if args.l33t:                 ②
    passwords = map(l33t, passwords)

print('\n'.join(passwords)) ③
```

① Use a list comprehension iterate through `range(args.num)` to generate the correct number of passwords.

② If the `args.leet` flag is `True`, then use the `l33t()` function to modify the `passwords`.

③ Print the `passwords` joined on newlines.

1.5. Review

This exercise kind of has it all. Validating user input, reading files, using a new data structure in the `set`, higher-order functions with `map()` and `filter()`, random values, and lots of functions and tests! I hope you enjoyed programming it, and maybe you'll even use the program to generate your new passwords. Be sure to share those passwords with your author, especially the ones to your bank account and favorite shopping sites!

1.6. Going Further

- The substitution part of the `l33t()` function changes every available character which perhaps makes the password too difficult to remember. It would be better to modify only maybe 10% of the password similar to how we changed the input strings in the "Telephone" exercise.
- Create programs that combine other skills you've learned. Like maybe a lyrics generator that randomly selects lines from a files of songs by your favorite bands, then encodes the text with the "Kentucky Friar," then changes all the vowels to one vowel with "Apples and Bananas," and then SHOUTS IT OUT with "The Howler"?

Congratulations, you are now 733+ HAX0R!

[1] See the Wiki page https://en.wikipedia.org/wiki/Leet or the Cryptii translator https://cryptii.com/

[2] You can run `pytest -xv unit.py` to run the unit tests. The program will import the various functions from your `password.py` file to test. Open `unit.py` and inspect it to understand how this happens!