CS134 Lecture 16:
Testing & Files

Announcements & Logistics

- No HW due tonight
- Lab 5 today/tomorrow (no prelab); due Friday noon (*after* midterm!)
- **Midterm reminders:**
  - **Review: Tonight 3/11** from 7-9pm
  - **Exam Thurs 3/14** from 6-7:30pm OR 8-9:30pm
  - Both exam and review are in Bronfman Auditorium
  - Exam only includes material up to last week (sets)
  - Sample Exam. Sample solutions posted (many possible ans)
- New Instructor Help Hours Schedule: Wed 1-4 pm, Thurs 1-4 pm

Do You Have Any Questions?

Last Time

- Explore another new Python type:
    - sets: *mutable* *unordered* collection
- Use tuples and sets in example functions

Lists, Tuples, Sets

Lists	**Tuples**	**Sets**
`list(), []`	`tuple(), ()`	`set()`
Mutable	**Immutable**	**Mutable**
Ordered	Ordered	Unordered
Store any type, even a list	Store any type, even a tuple	Immutable types, no duplicates
Dynamic datasets	Static ordered collections	Dynamic unordered collections
Indexing, slicing, len, in & not in, iteration in for loop	Indexing, slicing, len, in & not in, iteration in for loop	No indexing/slicing
		len, in & not in, iteration in for loop

Example in Class:

Using set to implement `get_candidates()`

Today's Plan

- Discuss **testing** and **debugging** strategies (more on this in Lab 5)
- Start discussion on how to read from and iterate over **files**
  - Tuple example to solve Madlibs problem

Testing and Debugging

Testing vs Debugging

- **Bugs** are mistakes in programs that cause them to behave incorrectly
- **Debugging**: Process of finding and fixing bugs in your code
    - These can be syntax errors, runtime errors, logical errors
- **Testing:** Process of revealing the presence of bugs
    - Ensuring that your code meets the specifications
    - Has the correct (expected) behavior on all inputs

Testing vs Debugging

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- **Debugging**: Process of finding and fixing bugs in your code
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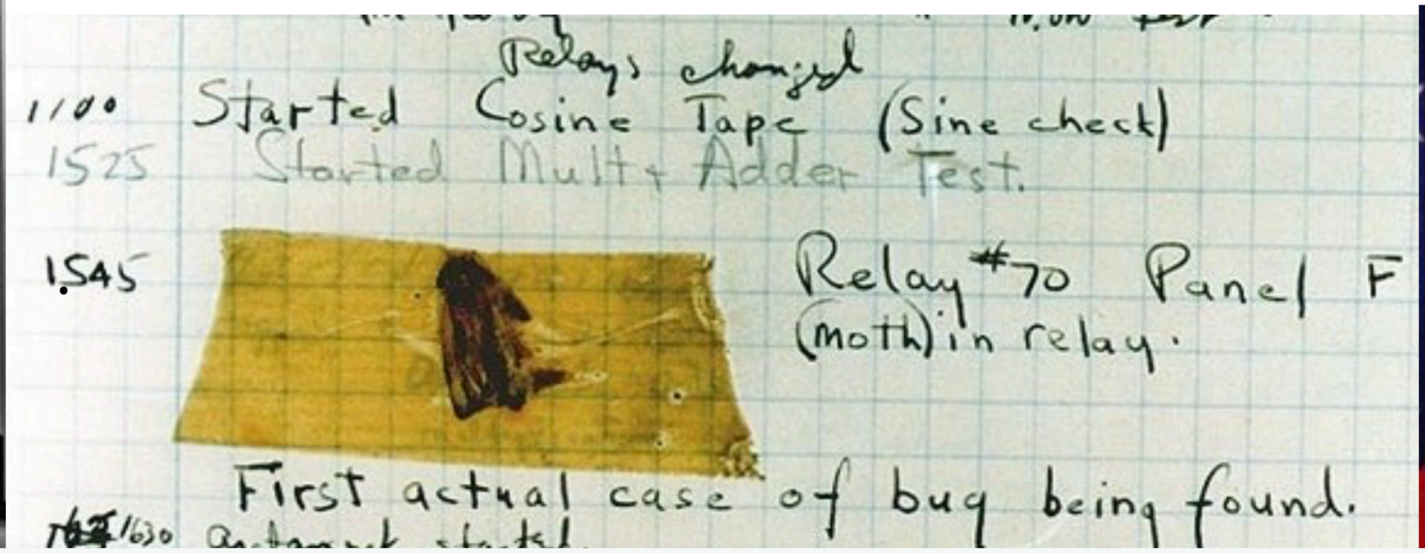
- **Testing:** Process of revealing the presence of bugs

One of the most famous bugs was an actual moth discovered by Grace Hopper in a relay when she was a programmer for Harvard's Mark II Aiken Relay computer in 1947. She had been a math professor at Vassar, was instrumental in the development of COBOL, joined the Navy in 1943, and rose to the rank Rear Admiral.



Relays changed
1100 Started Cosine Tape (Sine check)
1525 Started Mult+ Adder Test.
1545 Relay #70 Panel F (moth) in relay.
First actual case of bug being found.
1630 Arctangent started.

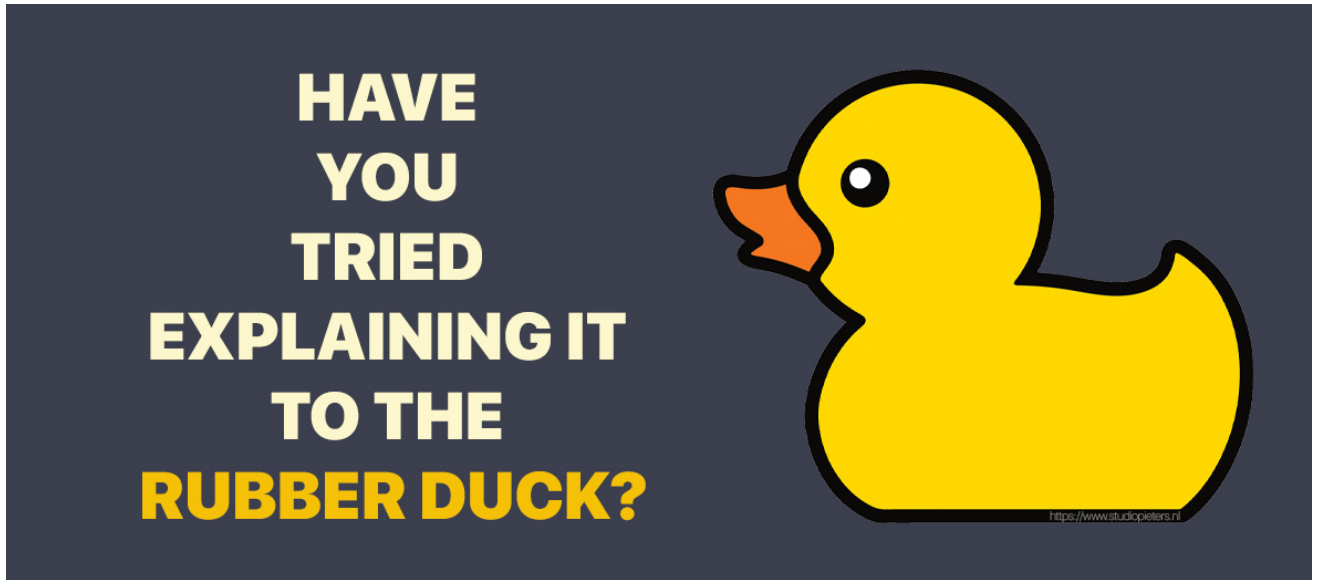
Types of Errors

- **Syntax errors:** Occurs when the code does not follow Python syntax rules
  - E.g., Missing colon after function definitions or if statements
  - Indentation issues
- **Runtime errors**: Occur when functions are invoked and variables are replaced by their values at runtime
  - E.g., divide by zero
- **Logical errors**: Occur due to mistakes in logic while implementing the functionality

How to Approach Debugging

- Read the Python error messages
  - Tells you line numbers and program trace
- Print statements
  - Print your accumulation variables, loop variables
  - Figure out how its changing and if it matches the logic
- Rubber duck debugging

Example in Notebook


HAVE YOU TRIED EXPLAINING IT TO THE RUBBER DUCK?
https://www.studiopieters.nl

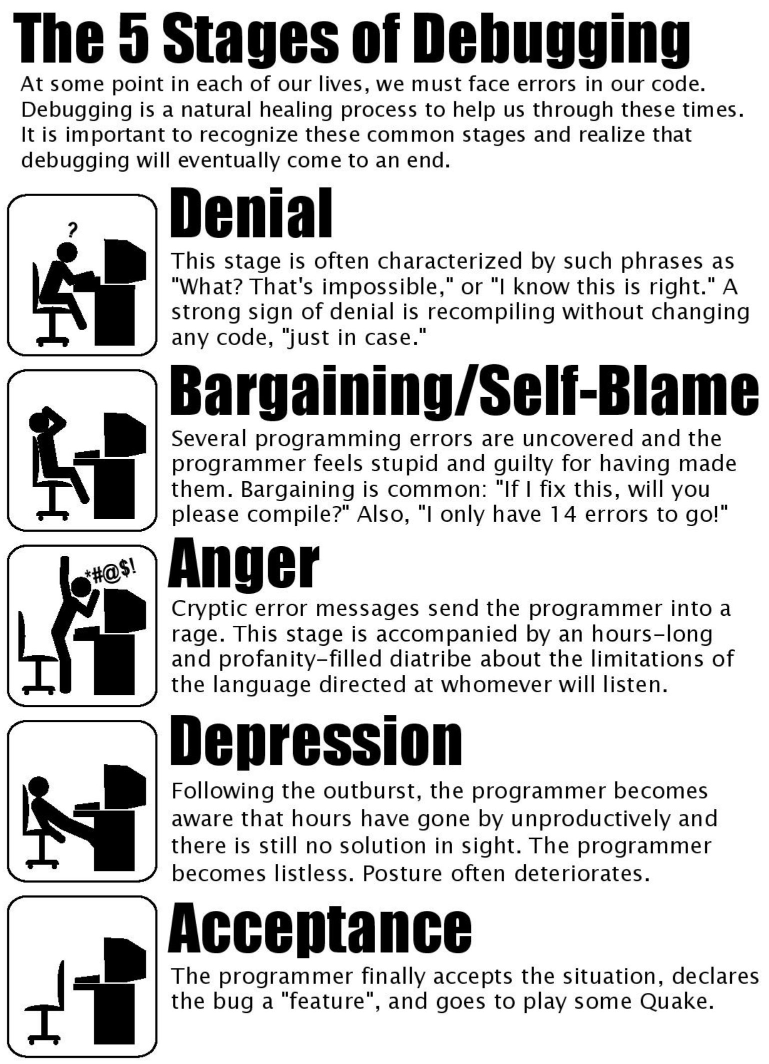
Testing Functions

- Many ways to test individual functions:
  - Interactive python:
    - Import into `python3` (interactive python) and call function
    - Copy paste into an **interactive notebook** and call function
  - Put function calls in the `if __name__ == "__main__":` block and run file as a script
  - Add test cases to `runtests.py`

Testing & Debugging Tips

- Edge cases:
  - Extreme cases that the function might not handle correctly
  - Test cases that force every conditional branch in the code to be executed at least once
- Loops:
  - Supply inputs that make the loop execute zero & most # times
  - Ensure any changing variables such as accumulation variables are updated appropriately
- Indexing:
    - ensure indices are always legal, check for "off by one" errors
- Comment out offending code until something worse!

Unexpected Joys of Debugging Code



The 5 Stages of Debugging

At some point in each of our lives, we must face errors in our code. Debugging is a natural healing process to help us through these times. It is important to recognize these common stages and realize that debugging will eventually come to an end.

Denial
This stage is often characterized by such phrases as "What? That's impossible," or "I know this is right." A strong sign of denial is recompiling without changing any code, "just in case."

Bargaining/Self-Blame
Several programming errors are uncovered and the programmer feels stupid and guilty for having made them. Bargaining is common: "If I fix this, will you please compile?" Also, "I only have 14 errors to go!"

Anger
Cryptic error messages send the programmer into a rage. This stage is accompanied by an hours-long and profanity-filled diatribe about the limitations of the language directed at whomever will listen.

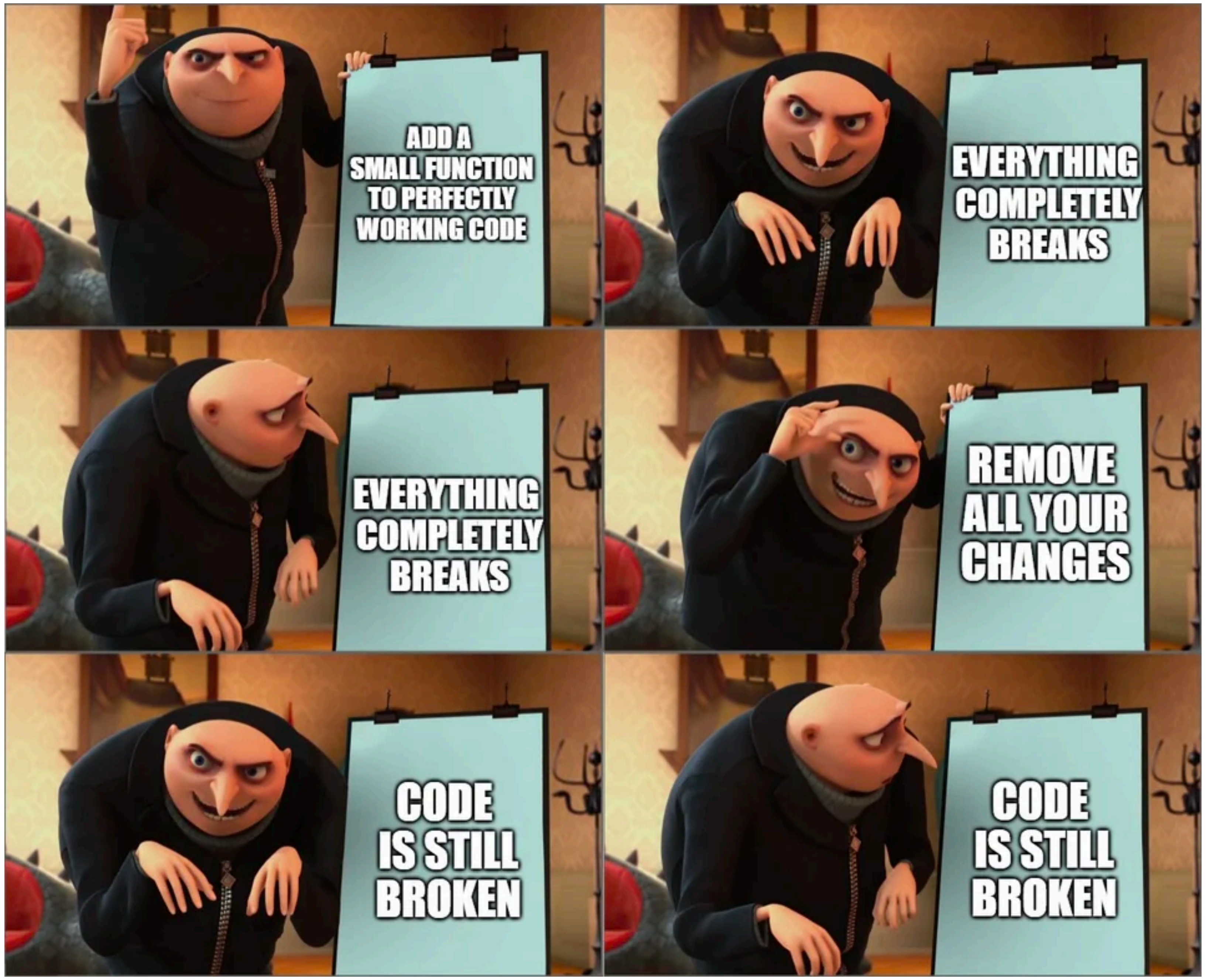
Depression
Following the outburst, the programmer becomes aware that hours have gone by unproductively and there is still no solution in sight. The programmer becomes listless. Posture often deteriorates.

Acceptance
The programmer finally accepts the situation, declares the bug a "feature", and goes to play some Quake.

https://www.linkedin.com/pulse/unexpected-joys-debugging-code-chris-nillissen

Testing is helpful!

- Credit to u/HuJohner


ADD A SMALL FUNCTION TO PERFECTLY WORKING CODE
EVERYTHING COMPLETELY BREAKS
EVERYTHING COMPLETELY BREAKS
REMOVE ALL YOUR CHANGES
CODE IS STILL BROKEN
CODE IS STILL BROKEN

runtests.py

runtests.py

- `runtests.py` typically has ~5 sections:
    - imports, datasets, our tests, your tests, and the test runner
- **Imports:** makes the functions we wrote in other files usable in this one
- **Datasets:** loads-in some handy datasets for testing the code
- **Our Tests:** Some basic tests we provide to see if your functions have minimal functionality
- **Your Tests:** A place where you should add your own tests, for ensuring maximal functionality
- **Test Runner:** Gathers command-line input (e.g., 'q2') and runs the tests specified in the body

runtests.py

- **To add your own tests:** copy a similar example from our tests into the function body, update the parameters and print statements.

```python
def my_first_choice_votes_test():
    # Replace the following line with your own test!
    print("YOU HAVEN'T YET WRITTEN YOUR OWN TEST FOR first_choice_votes!")
```

```python
def my_first_choice_votes_test():
    result = first_choice_votes(aamir_beth_chris_ballots())
    print("first_choice_votes(aamir_beth_chris_ballots())")
    print("  should return:  ['Aamir', 'Beth', 'Chris', 'Aamir']")
    print("  yours returned: " + str(result))
```

- If you're using a function header already provided in the .py file, then this function will run!

runtests.py

- If you've made a brand ***new*** function with a new name, you'll need to make sure that function is called in the **Test Runner**

```
if __name__ == "__main__":
    args = get_command_line_args()
    if len(args) == 0:  # if there are no command-line arguments
        print("Please specify the question: q1, q2, q3, q4, q5, q6, q7, q8, q9")
    else:
        which_question = args[0]  # reads the first command-line argument
        if which_question == "q1":
            first_choice_votes_test1()
            first_choice_votes_test2()
            my_first_choice_votes_test()
```

Reading Data from Files

Working with Files in Python

- File I/O is a very common and important operation
- `open(filename)` is a built-in Python function for working with files
  - `filename` is a path to a file as a **string**
- Using `open()` within a `with … as` code block, we can **iterate** over the **lines of a text file** just as we iterated over strings and lists in previous lectures

Opening Files: `with … as`

Path to file on computer as a string

```
with open(filename) as input_file:
        # do something with file
```

Variable name for your file

Note. **(syntax)** Indentation defines the body of the with block where the file is open. File automatically closed after with…as block.

Iterating over Lines in a File

- Within a `with open(filename) as input_file:` block, we can iterate over the lines in the file just as we would iterate over any sequence such as lists, strings, or ranges
- The end of a line in the text file is determined by the special newline character `'\n'`
- Example: We have a text file `mountains.txt` within a directory `data`. We can iterate and print each line as follows:

```
with open("data/mountains.txt") as book:
    for line in book:
        print(line)
```

```
O, proudly rise the monarchs of our

With their kingly forest robes, to the sky,

Where Alma Mater dwelleth with her chosen ba

And the peaceful river floweth gently by.
```

Variable name for your file

Path to file on computer as a string

`'\n'` between each line

Iterating over Lines in a File

- Because the end of the line in a file is a newline character `'\n'` and when we `print(a_string)` a newline character is added to the end…we end up with an empty newline between each printed line!

```python
with open("data/mountains.txt") as book:
    result = []
    for line in book:
        result += [line]
    print(result)
```

```
['O, proudly rise the monarchs of our mountain land,\n',
 'With their kingly forest robes, to the sky,\n',
 'Where Alma Mater dwelleth with her chosen band,\n',
 'And the peaceful river floweth gently by.\n']
```

Removing Leading/Trailing Whitespace from a String

- Because the end of the line in a file is a newline character `'\n'` and when we `print(a_string)` a newline character is added to the end...we end up with an empty newline between each printed line!
- Let's write a function that will remove leading and trailing whitespaces.

```
s = '\n  \t  String with\t different\nspaces.\r\n\t'
```

`'\n'` newline

`'\t'` newline

`'\r'` return

```
spaces = ['\n', '\t', '\r', ' ']
```

```
>>> len('\n')
1
```

`'\n'` is one character! The backslash *escapes* the character.

Removing Leading/Trailing Whitespace from a String

- Let's write a function that will remove leading and trailing whitespaces.

```
def strip(line):
   # handle empty line somehow
        # return line?
    spaces = ['\n', '\t', '\r', ' ']

    # find where the words start
    # look at each character
    # if it's a space...keep looking
        # keep track of indices looked at

    # find where the word ends
    # look at each character in reverse
    # if it's a space...keep looking
        # keep track of indices looked at

    # return the string between the start and end index
```

Removing Leading/Trailing Whitespace from a String

- Let's write a function that will remove leading and trailing whitespaces.

```python
def strip(line):
    if not line: # handle empty line
        return line
    spaces = ['\n', '\t', '\r', ' ']

    # find the first not-space
    start_index = 0
    while start_index<len(line) and line[start_index] in spaces:
        start_index += 1

    # find the last not-space
    end_index = len(line)-1
    while end_index>0 and line[end_index] in spaces:
        end_index -= 1

    return line[start_index:end_index+1]
```

```
>>> s = '\n  \t  String with\t different\nspaces.\r\n\t'
>>> strip(s)
'String with\t different\nspaces.'
```

Useful String and List Functions in File Reading

- When reading files, we may need to use some common string and list operations to work with the data.
- We'll learn about the built-in features python has for these later in the semester, but we can write our own with iterating over strings and accumulator variables!
    - `strip(line):` Remove any leading/trailing white space or "\n"
    - `split(line, ','):` Separate a **comma-separated** sequence of words and create a list of strings
    - `join(' ', lines):` Create a single "big" string with words separated by spaces instead of commas
    - `count_appearances(ele, let):` Count the occurrence of various elements
    - …and so on!