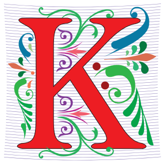
Compsci 101
List Comprehensions, Parallel Lists

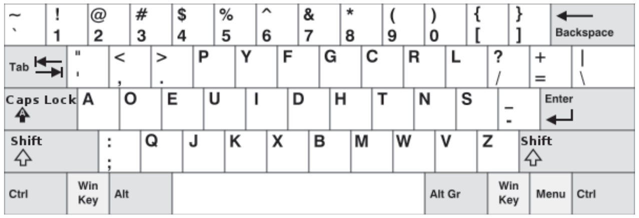
Susan Rodger

Feb 21, 2023

K is for …



- **Kernel**
  - Core of the OS, Core for Machine Learning
- **Keyboard - QWERTY or DVORAK**
  - DVORAK:


~ ` ! 1 @ 2 # 3 $ 4 % 5 ^ 6 & 7 * 8 (9) 0 { [}] Backspace
Tab " ' < , > . P Y F G C R L ? / + = | \
Caps Lock A O E U I D H T N S _ - Enter
Shift : ; Q J K X B M W V Z Shift
Ctrl Win Key Alt Alt Gr Win Key Menu Ctrl

- **Key and (Key,Value) pair**
  - Heart of a dictionary

Tiffany Chen

- **Duke BS - IDM CS/Biology**
- **Stanford PhD Biomedical Informatics (CS and Biomedicine)**
- **Was Director of Informatics, Cytobank**
- **Now Group Product Manager at Chan Zuckerberg Inititave**

"Part of the advantage of being interdisciplinary is that you can see the big picture when no one else can, and you can communicate to everyone else what that big picture is"

"If you are interested in a PhD, I would suggest doing a summer research experience as an undergraduate, but also an internship in industry. You can see how problems are solved in the real world"

Announcements

- **APT-3 due Thursday**
- **Assign 3-Transform out today, due Thursday, March 2**
  - Sakai quiz Assign3 – Due Tues, Feb 28 (no grace day)
- **Lab 6 Friday - Prelab out today**
- **APT Quiz 1 is Thurs Feb 23-Mon Feb 27**
  - Take during this time
  - Two parts – each part has two APTs
  - Each part is timed

PFTD

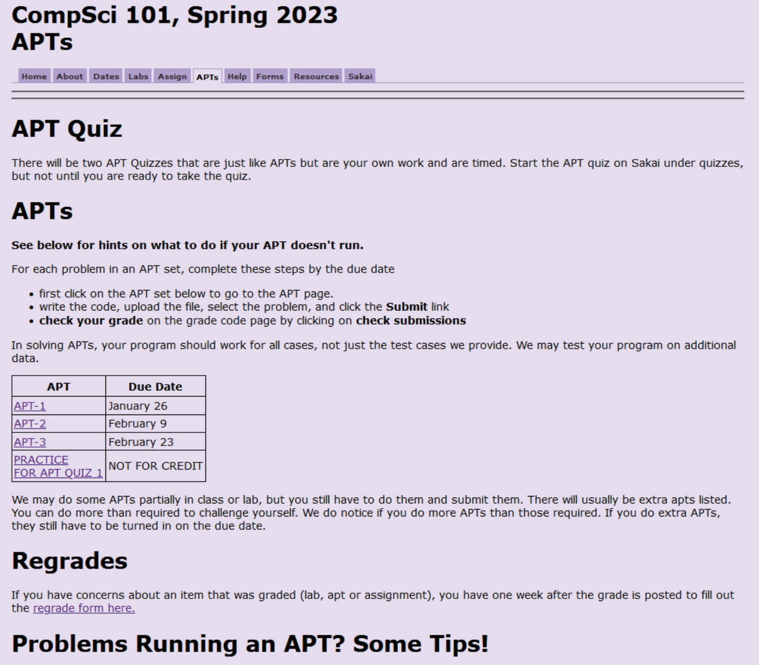
- **APT Quiz 1**
- **Pancakes**
- **Parallel Lists**
- **List Comprehensions**
- **Assignment 3 - Transform Assignment**

APT Quiz 1 Feb 23-27

- **Opens 2/23 1pm**
- **Closes at 11pm 2/27– must finish all by this time**
- **There are two parts based on APTs 1-3**
  - Each part has two APT problems
  - Each part is 2 hours – more if you get accommodations
  - Each part starts in Sakai under tests and quizzes
  - Sakai is a starting point with countdown timer that sends you to a new apt page just for each part
  - Could do each part on different day or same days
- **Old APT Quiz so you can practice (not for credit) – on APT Page**

APT Quiz 1

- **Is your own work!**
  - No collaboration with others!
  - Use your notes, lecture notes, your code, textbook
  - DO NOT search for answers! No Chat-GPT!
  - Do not talk to others about the quiz until grades are posted
- **Post private questions on Ed Discussion**
  - We are not on between 9pm and 9am!
  - We are not on all the time, especially weekends
  - Will try to answer questions between 9am – 9pm
    - About typos, cannot help you in solving APTs
- **See 101 APT page for tips on debugging APTs**



CompSci 101, Spring 2023
APTs

APT Quiz

There will be two APT Quizzes that are just like APTs but are your own work and are timed. Start the APT quiz on Sakai under quizzes, but not until you are ready to take the quiz.

APTs

See below for hints on what to do if your APT doesn't run.

For each problem in an APT set, complete these steps by the due date

- first click on the APT set below to go to the APT page.
- write the code, upload the file, select the problem, and click the **Submit** link
- **check your grade** on the grade code page by clicking on **check submissions**

In solving APTs, your program should work for all cases, not just the test cases we provide. We may test your program on additional data.

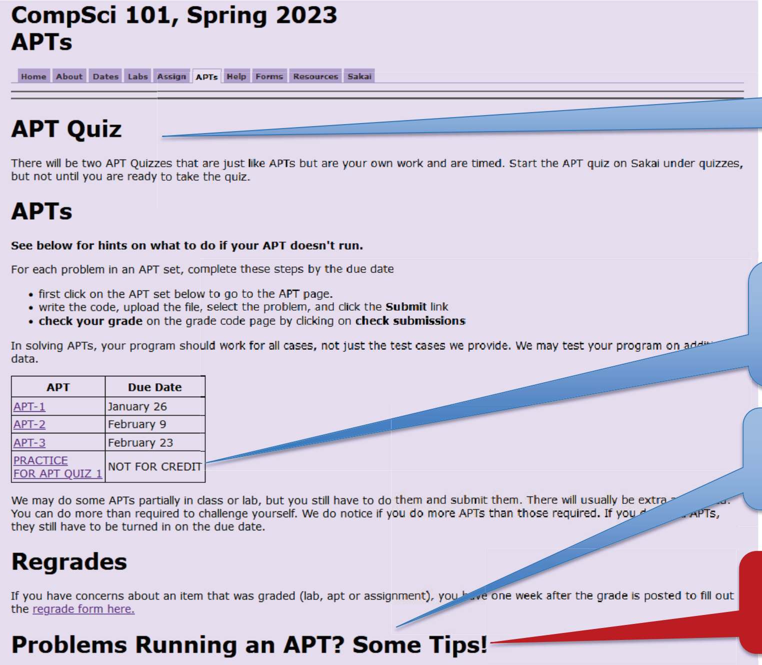
APT	Due Date
APT-1	January 26
APT-2	February 9
APT-3	February 23
PRACTICE FOR APT QUIZ 1	NOT FOR CREDIT

We may do some APTs partially in class or lab, but you still have to do them and submit them. There will usually be extra apts listed. You can do more than required to challenge yourself. We do notice if you do more APTs than those required. If you do extra APTs, they still have to be turned in on the due date.

Regrades

If you have concerns about an item that was graded (lab, apt or assignment), you have one week after the grade is posted to fill out the regrade form here.

Problems Running an APT? Some Tips!



CompSci 101, Spring 2023
APTs

APT Quiz

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Problems Running an APT? Some Tips!

APT Quiz Info

Practice (old APT quiz)

Debugging Tips

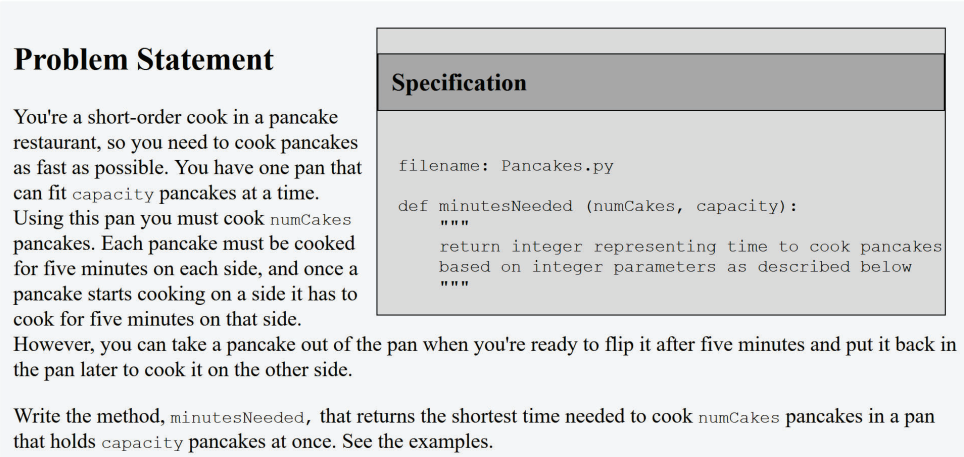
Stuck! Use 7 steps!

Pancakes!

APT Pancake

- **How do you solve this (or any) problem?**
  - 7 Steps!
- **Some APTs are hard problems to solve (step 1-4)**
  - Translating to code easy
- **Some APTs have easy-to-see algorithms (step 5)**
  - Translating to code is hard

APT: Pancakes



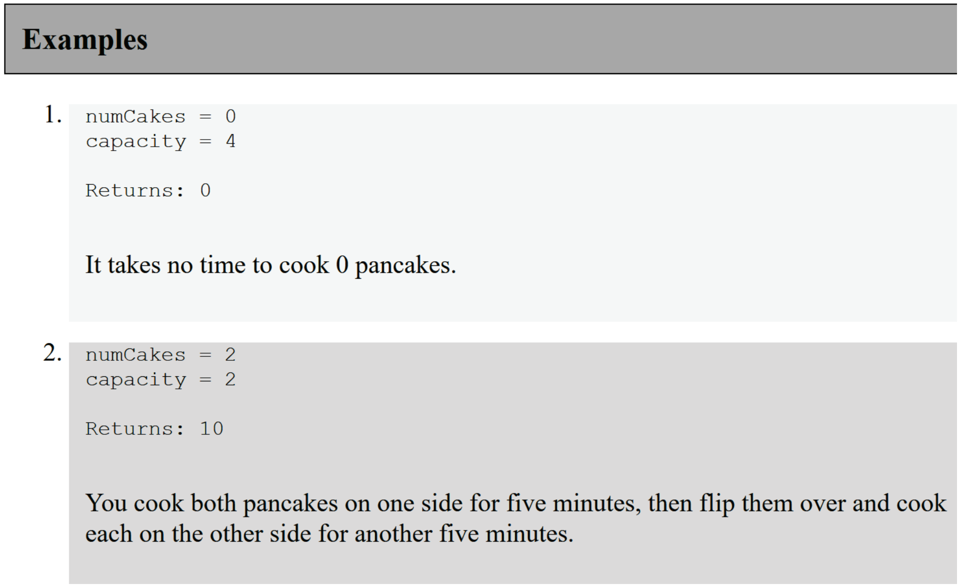
Problem Statement

Specification

```
filename: Pancakes.py

def minutesNeeded (numCakes, capacity):
    """
    return integer representing time to cook pancakes
    based on integer parameters as described below
    """
```

You're a short-order cook in a pancake restaurant, so you need to cook pancakes as fast as possible. You have one pan that can fit `capacity` pancakes at a time. Using this pan you must cook `numCakes` pancakes. Each pancake must be cooked for five minutes on each side, and once a pancake starts cooking on a side it has to cook for five minutes on that side. However, you can take a pancake out of the pan when you're ready to flip it after five minutes and put it back in the pan later to cook it on the other side.

Write the method, `minutesNeeded`, that returns the shortest time needed to cook `numCakes` pancakes in a pan that holds `capacity` pancakes at once. See the examples.



Examples

1.
```
numCakes = 0
capacity = 4

Returns: 0
```

It takes no time to cook 0 pancakes.

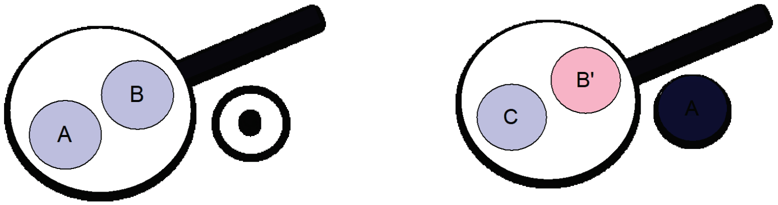
2.
```
numCakes = 2
capacity = 2

Returns: 10
```

You cook both pancakes on one side for five minutes, then flip them over and cook each on the other side for another five minutes.

Step 1: Solve an instance

Three pancakes in a two-cake pan

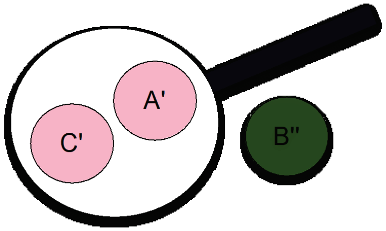
- First 5 minutes
  - 2 half cooking
  - 1 uncooked
- Second 5 minutes
  - 2 half cooking
  - 1 almost cooked



Step 1: Solve an instance

Three pancakes in a two-cake pan

- Third 5 minutes
  - 1 done
  - 2 almost cooked
- How many minutes to cook all three pancakes?



15 minutes!

Step 1: Solve an instance

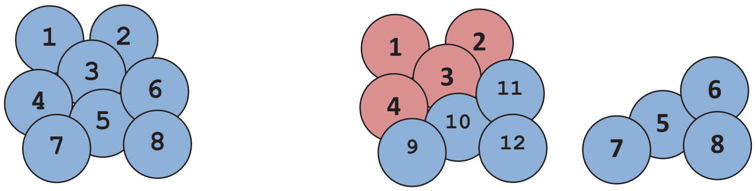
- **What kind of instances? Simple cases that are quickly solved**
  - What are these in Pancake problem?
- **Don't solve for N, solve for 5 (generalize is step 3)**
  - What to do when there are two parameters?
    - Fix one, vary the other one
  - Helps identify cases

WOTO-1 Pancakes
http://bit.ly/101s23-0221-1

Step 1: Solve an instance

- **Pan has capacity 8, vary # pancakes**
  - Can you cook 12 in 15 minutes? Why?
  - Can you cook 13 in 15 minutes? Why?

cakes	5	6	7	8	9	10	11	12	13	14	15	16	17	18
time	10	10	10	10	?									



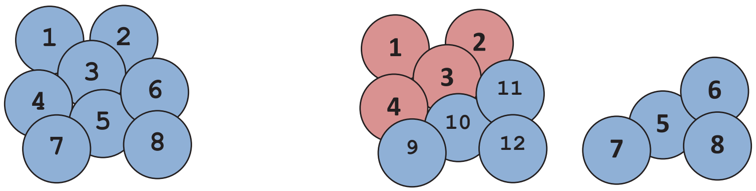
Step 2: What did we just do?

- **13 – 8 = 5**
- **8/2 = 4 # Can only take off up to half**
- **Is 5 <= 4?**
  - No, warmer trick won’t work
- **10 minutes for 8 pancakes + 10 minutes for 5 more pancakes = 20 minutes**

Step 1: Solve an instance

- **Pan capacity 8, vary # pancakes, 17 pancakes?**

cakes	5	6	7	8	9	10	11	12	13	14	15	16	17	18
time	10	10	10	10	15	15	15	15	20	20	20	20		



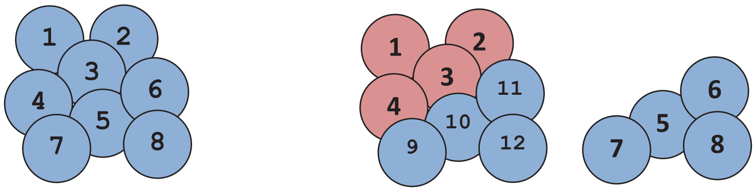
Step 2: What did we just do?

- **17 – 8 = 9, 9 – 8 = 1**
- **8/2 = 4**
- **Is 1 <= 4? # Yes, warmer trick will work!**
- **Total: 25 minutes**
  - 10 minutes for 8 pancakes +
  - 5 minutes for 8 pancakes +
  - Take 1 out, start 17th pancake
  - 5 minutes finish pancakes 8 to 15 +
  - 5 minutes finish pancake 16 and 17

Step 3: Generalize

- **Pan has capacity 8, Generalize to algorithm?**

cakes	5	6	7	8	9	10	11	12	13	14	15	16	17	18
time	10	10	10	10	15	15	15	15	20	20	20	20	25	25



Step 3: Generalize

- 13 – 8 = 5
- 8/2 = 4
- Is 5 <= 4?
  - No, warmer trick won't work
- 10 minutes for 8 pancakes + 10 minutes for 5 more pancakes = 20 minutes

- Remove as many as can with panCapacity
- Will the remainder fit in half the pan?
- Yes, use warmer
  - 5 minutes instead of 10 for last batch
- No, don't use warmer
  - 10 minutes for all sets of panCapacity

Step 4: Test Steps

- Remove as many as can with panCapacity
- Will the remainder fit in half the pan?
- Yes, use warmer
  - 5 minutes instead of 10 for last batch
- No, don't use warmer
  - 10 minutes for all sets of panCapacity

- Case 1:
  - cap 17, cook 34

Step 4: Test Steps

- Remove as many as can with panCapacity
- Will the remainder fit in half the pan?
- Yes, use warmer
  - 5 minutes instead of 10 for last batch
- No, don't use warmer
  - 10 minutes for all sets of panCapacity

- Case 1:
  - cap 17, cook 34
  - remainder = 0
  - Edge case! No need for warmer
  - Total: 20 minutes
- Case 2:
  - cap 17, cook 42

Step 4: Test Steps

- Remove as many as can with panCapacity
- Will the remainder fit in half the pan?
- Yes, use warmer
  - 5 minutes instead of 10 for last batch
- No, don't use warmer
  - 10 minutes for all sets of panCapacity

- Case 1:
  - cap 17, cook 34
  - remainder = 0
  - Edge case! No need for warmer
  - Total: 20 minutes
- Case 2:
  - cap 17, cook 42
  - remainder = 8
  - Yes, use warmer
  - Total: 25 minutes

Step 5: Code

- Remove as many as can with panCapacity
- Will the remainder fit in half the pan?
- Yes, use warmer
  - 5 minutes instead of 10 for last batch
- No, don't use warmer
  - 10 minutes for all sets of panCapacity

- N pancakes
- How many panCapacity can remove?
  - N // panCapacity
- remainder
  - N % panCapacity
- Half of pan?
  - panCapacity / 2

Let's code it up!

```
def minutesNeeded(numCakes, capacity):
    full = numCakes // capacity
    left = numCakes % capacity
    minutes = 10 * full
    if left > capacity/2:
        minutes += 10
    else:
        minutes += 5
    return minutes
```

Very Close! Has a slight bug in it!

Pancake flipping Video

How to teach pancake Flipping

- http://www.youtube.com/watch?v=W_gxLKSsSIE
  - For longer, more complex robotic tasks
    - http://www.youtube.com/watch?v=4usoE981e7I

Robot learns to flip pancakes

PetarKormushev 2 videos Subscribe

Demonstration of the task

Problem

- **Given a file of words, which word occurs the most**

- **For each word count how many times it occurs**
- **Determine which word has the highest count**

Parallel Lists

- **We will use parallel lists to track data**
  - Each word is stored in a list named **`words`**
  - Word's count is stored in a list named **`counts`**
  - # occurrences of **`words[k]`** is in **`counts[k]`**

words

```
["apple", "fox", "vacuum", "lime"]
[   5,       2,       25,       15  ]
```

counts

Parallel Lists

- **We will use parallel lists to track data**
  - Each word is stored in a list named **`words`**
  - Word’s count is stored in a list named **`counts`**
  - # occurrences of **`words[k]`** is in **`counts[k]`**

words[0]

```
["apple", "fox", "vacuum", "lime"]
[    5,       2,       25,       15   ]
```

counts[0]

- **For example: “apple” has been seen five times**

Parallel Lists

- **We will use parallel lists to track data**
  - Each word is stored in a list named **`words`**
  - Word’s count is stored in a list named **`counts`**
  - # occurrences of **`words[k]`** is in **`counts[k]`**

words[2]

```
["apple", "fox", "vacuum", "lime"]
[    5,       2,       25,       15   ]
```

counts[2]

- **For example: “vacuum” has been seen 25 times**

Parallel Lists

- **We will use parallel lists to track data**
  - Each word is stored in a list named **`words`**
  - Word’s count is stored in a list named **`counts`**
  - # occurrences of **`words[k]`** is in **`counts[k]`**

```
["apple", "fox", "vacuum", "lime"]
[    5,       2,       25,       15   ]
```

- **What happens when we read a word?**

Read word “vacuum”?

Parallel Lists

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  - Each word is stored in a list named **`words`**
  - Word’s count is stored in a list named **`counts`**
  - # occurrences of **`words[k]`** is in **`counts[k]`**

words[2]

```
["apple", "fox", "vacuum", "lime"]
[    5,       2,       26,       15   ]
```

Add 1 to counts[2]

- **What happens when we read a word?**

Read word “vacuum”?

Parallel Lists

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  - Each word is stored in a list named **`words`**
  - Word's count is stored in a list named **`counts`**
  - # occurrences of **`words[k]`** is in **`counts[k]`**

```
["apple", "fox", "vacuum", "lime"]
[    5,        2,        26,       15   ]
```

- **What happens when we read a word?**

Read word "cat"?

Parallel Lists

- **We will use parallel lists to track data**
  - Each word is stored in a list named **`words`**
  - Word's count is stored in a list named **`counts`**
  - # occurrences of **`words[k]`** is in **`counts[k]`**

Add into words

```
["apple", "fox", "vacuum", "lime", "cat"]
[    5,        2,        26,       15   ]
```

- **What happens when we read a word?**

Read word "cat"?

Parallel Lists

- **We will use parallel lists to track data**
  - Each word is stored in a list named **`words`**
  - Word's count is stored in a list named **`counts`**
  - # occurrences of **`words[k]`** is in **`counts[k]`**

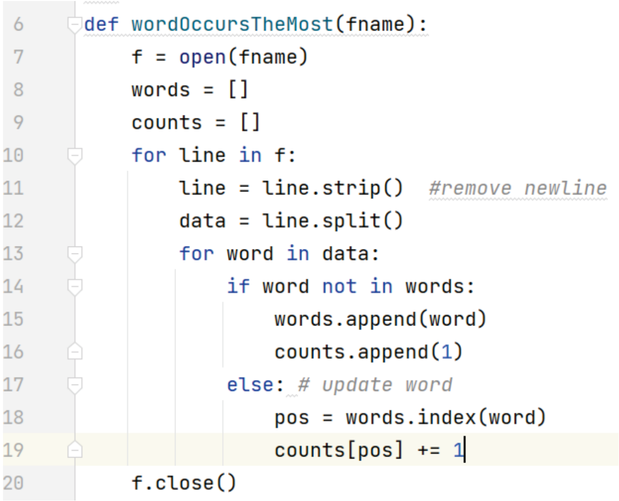
```
["apple", "fox", "vacuum", "lime", "cat"]
[    5,        2,        26,       15,       1   ]
```

Expand counts

- **What happens when we read a word?**

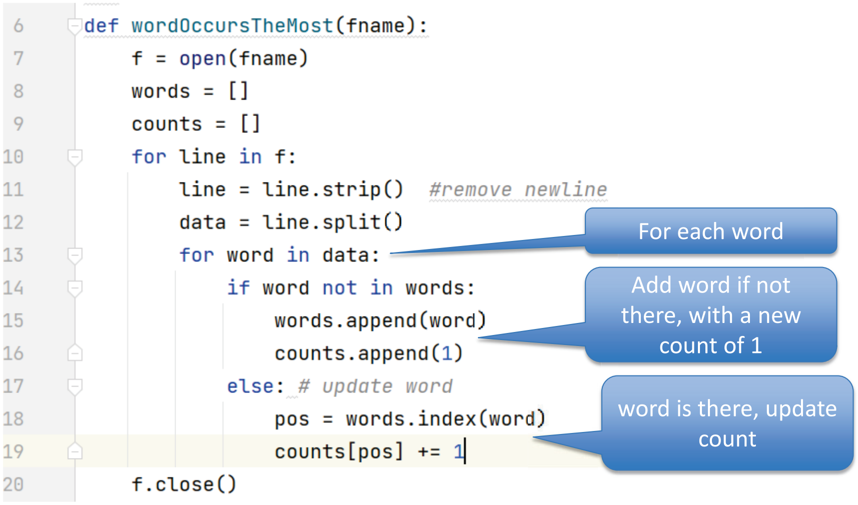
Read word "cat"?

Calculate word most often in file



```
def wordOccursTheMost(fname):
    f = open(fname)
    words = []
    counts = []
    for line in f:
        line = line.strip()  #remove newline
        data = line.split()
        for word in data:
            if word not in words:
                words.append(word)
                counts.append(1)
            else: # update word
                pos = words.index(word)
                counts[pos] += 1
    f.close()
```

Calculate word most often in file



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    counts = []
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        data = line.split()
        for word in data:
            if word not in words:
                words.append(word)
                counts.append(1)
            else: # update word
                pos = words.index(word)
                counts[pos] += 1
    f.close()
```

For each word

Add word if not there, with a new count of 1

word is there, update count

How do you finish the function?

WOTO-2 Word Most Often
http://bit.ly/101s23-0221-2

Calculate word most often in file

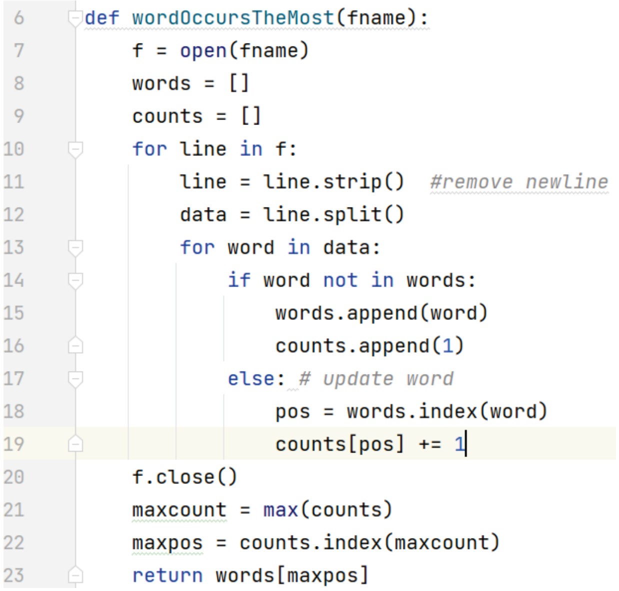
- **words is list of all the words from the file**
- **counts is the count of each word in the file**
- **Find the largest count value**

  maxcount = max(counts)
- **Find index location of largest count value**

  maxpos = counts.index(maxcount)
- **Return word in same location**

  return words[maxpos]

Complete function:



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    counts = []
    for line in f:
        line = line.strip()  #remove newline
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        for word in data:
            if word not in words:
                words.append(word)
                counts.append(1)
            else: # update word
                pos = words.index(word)
                counts[pos] += 1
    f.close()
    maxcount = max(counts)
    maxpos = counts.index(maxcount)
    return words[maxpos]
```

List Comprehension Accumulator in one line

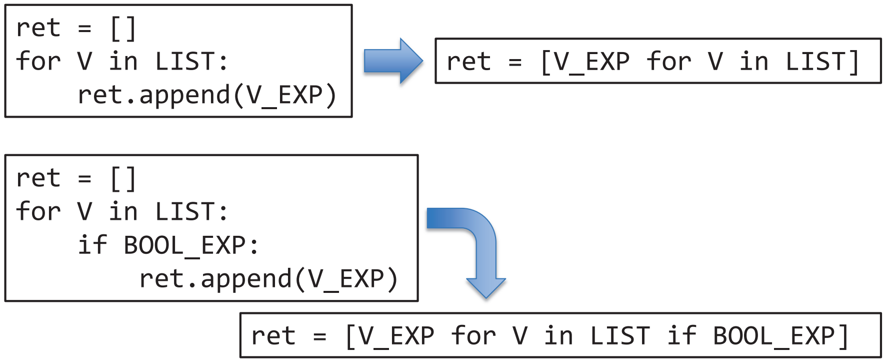
```
def onlyPos(nums):
    ret = []
    for n in nums:
        if n > 0:
            ret.append(n)
    return ret

print(onlyPos([1,2,3,-1,-2,-3]))
```

```
return [n for n in nums if n > 0]
```

- **List Comprehension**
  - We will use a complete, but minimal version of list comprehensions, much more is possible

List Comprehension Syntax



```
ret = []
for V in LIST:
    ret.append(V_EXP)
```

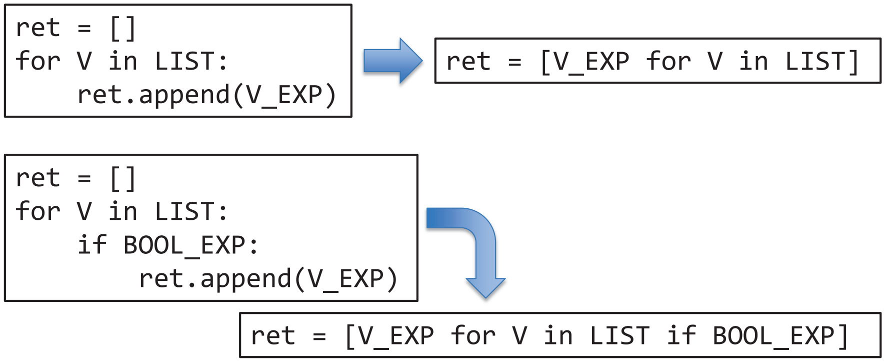
```
ret = [V_EXP for V in LIST]
```

```
ret = []
for V in LIST:
    if BOOL_EXP:
        ret.append(V_EXP)
```

```
ret = [V_EXP for V in LIST if BOOL_EXP]
```

- **V is any variable: all list elements in order**
- **V_EXP is any expression, often use V**

List Comprehension Syntax



```
ret = []
for V in LIST:
    ret.append(V_EXP)
```

```
ret = [V_EXP for V in LIST]
```

```
ret = []
for V in LIST:
    if BOOL_EXP:
        ret.append(V_EXP)
```

```
ret = [V_EXP for V in LIST if BOOL_EXP]
```

- **if part optional - BOOL_EXP is a Boolean expression usually using V**

List Comprehension Examples

print([n*2 for n in range(6)])

print([n for n in range(10) if n % 2 == 1])

List Comprehension Examples

```
print( [n*2 for n in range(6)] )
```

```
[0, 2, 4, 6, 8, 10]
```

```
print( [n for n in range(10) if n % 2 == 1] )
```

```
[1, 3, 5, 7, 9]
```

List Comprehension Examples

```
print( [n/2 for n in range(10) if n % 2 == 0] )
```

```
lst = [‘banana’, ‘pineapple’, ‘apple’]
print( [c for c in lst if ‘n’ in c] )
```

List Comprehension Examples

```
print( [n/2 for n in range(10) if n % 2 == 0] )
```

```
[0, 1, 2, 3, 4]
```

```
lst = [‘banana’, ‘pineapple’, ‘apple’]
print( [c for c in lst if ‘n’ in c] )
```

```
[‘banana’, ‘pineapple’]
```

WOTO-3 List Comprehension Examples

http://bit.ly/101s23-0221-3

WOTO-3 List Comprehension Example

```
words = ['giraffe', 'zebra', 'ant', 'lion', 'elephant']
x = [2*x for x in [len(w) for w in words if len(w)>3] if x%2== 0]
```

Don't do this!!!

```
words = ['giraffe', 'zebra', 'ant', 'lion', 'elephant']
y = [len(w)    for w in words    if len(w) > 3]
x = [2*x   for x in y    if x%2== 0]
```

Break it up to two list comprehensions

y is [7, 5, 4, 8]

x is [8, 16]

Difficult to debug!!!

Assignment 3: Transform

- **Reading and writing files**
  - We've seen how to read, writing is similar
  - Open, read, and close
  - Open, write, and close - `.write(…)`
- **Apply a function to every word in a file**
  - Encrypt and decrypt
  - Respect lines, so resulting file has same structure

Encrypting and Decrypting

- **We give you:**
  - Transform.py
  - Vowelizer.py - Removes vowels, then re-vowelize
- **You implement**
  - Pig Latin
  - Caesar cipher
- **Challenge: Shuffleizer**

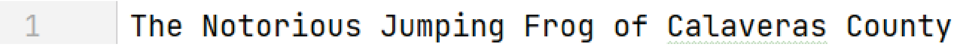
Concepts in Starter Code

- **Global variables**
  - Generally avoided, but very useful
  - Accessible in all module functions
- **FileDialog and tkinter**
  - API and libraries for building UI and UX
- **Docstrings for understanding!**

Look at code

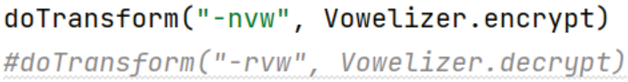
Transform – Remove Vowels

- **First line of twain.txt:**



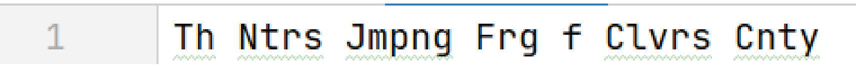
```
The Notorious Jumping Frog of Calaveras County
```

- **Run Transform.py on twain.txt**
- **Set as:**



```
doTransform("-nvw", Vowelizer.encrypt)
#doTransform("-rvw", Vowelizer.decrypt)
```

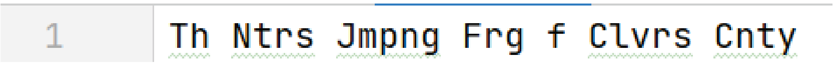
- **Results in new file: twain-nvw.txt**
- **First line of twain-nvw.txt is:**



```
Th Ntrs Jmpng Frg f Clvrs Cnty
```

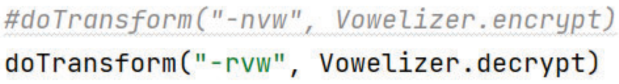
Transform – Get vowels back?

- **First line of twain-nvw.txt:**



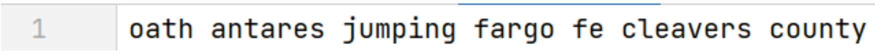
```
Th Ntrs Jmpng Frg f Clvrs Cnty
```

- **Run Transform.py on twain-nvw.txt**
- **Set as:**



```
#doTransform("-nvw", Vowelizer.encrypt)
doTransform("-rvw", Vowelizer.decrypt)
```

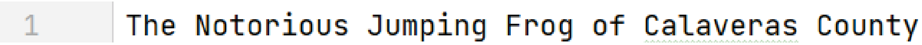
- **Results in new file: twain-nvw-rvw.txt**
- **First line of twain-nvw-rvw.txt is:**



```
oath antares jumping fargo fe cleavers county
```

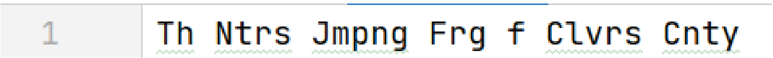
Transform – Vowels summary

- **First line in twain.txt**



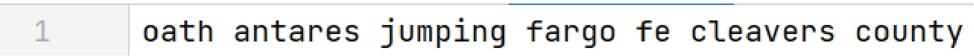
```
The Notorious Jumping Frog of Calaveras County
```

- **After removing vowels – "encrypt"**



```
Th Ntrs Jmpng Frg f Clvrs Cnty
```

- **After trying to re-vowelize – "decrypt"**



```
oath antares jumping fargo fe cleavers county
```