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# CS 1110 Prelim 1 October 12th, 2017

This 90-minute exam has 6 questions worth a total of 100 points. Scan the whole test before starting. Budget your time wisely. Use the back of the pages if you need more space. You may tear the pages apart; we have a stapler at the front of the room.

**It is a violation of the Academic Integrity Code to look at any exam other than your own, to look at any other reference material, or to otherwise give or receive unauthorized help.**

You will be expected to write Python code on this exam. We recommend that you draw vertical lines to make your indentation clear, as follows:

```
def foo():
|   if something:
|   |   do something
|   |   do more things
|   do something last
```

Do not use recursion on this exam. Beyond that, you may use any Python feature that you have learned in class (if-statements, try-except, lists, for-loops and so on), **unless directed otherwise**.

| Question | Points | Score |
|---|---|---|
| 1 | 2 | |
| 2 | 14 | |
| 3 | 22 | |
| 4 | 20 | |
| 5 | 22 | |
| 6 | 20 | |
| Total: | 100 | |

**The Important First Question:**

1. [2 points] Write your last name, first name, and netid, at the top of *each* page.

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## Reference Sheet

Throughout this exam you will be asked questions about strings and lists. You are expected to understand how slicing works. In addition, the following functions and methods may be useful.

### String Functions and Methods

| Function or Method | Description |
|---|---|
| `len(s)` | **Returns**: number of characters in `s`; it can be 0. |
| `s.find(s1)` | **Returns**: index of the first character of the FIRST occurrence of `s1` in `s` (-1 if `s1` does not occur in s). |
| `s.find(s1,n)` | **Returns**: index of the first character of the first occurrence of `s1` in `s` STARTING at position n. (-1 if `s1` does not occur in s from this position). |
| `s.upper()` | **Returns**: A copy of `s`, all letters converted to upper case. |
| `s.lower()` | **Returns**: A copy of `s`, all letters converted to lower case. |
| `s.isalpha()` | **Returns**: True if `s` is *not empty* and its elements are all letters; it returns False otherwise. |
| `s.isdigit()` | **Returns**: True if `s` is *not empty* and its elements are all numbers; it returns False otherwise. |

### List Functions and Methods

| Function or Method | Description |
|---|---|
| `len(x)` | **Returns**: number of elements in list `x`; it can be 0. |
| `x.index(y)` | **Returns**: index of the FIRST occurrence of `y` in `x` (an error occurs if `y` does not occur in `x`). |
| `x.append(y)` | Adds `y` to the end of list `x`. |
| `x.insert(i,y)` | Inserts `y` at position `i` in list `x`, shifting later elements to the right. |
| `x.remove(y)` | Removes the first item from the list whose value is `y`. (an error occurs if `y` does not occur in `x`). |

The last three list methods are all procedures. They return the value `None`.

2. [14 points total] **Short Answer Questions.**

(a) [3 points] What values are printed out to the screen after the following commands?

```
>>> a = [1,2,3]                         [1,5,2,3] # The new value of a
>>> b = a[:]                            [1,2,3]   # The copied value of b
>>> c = a
>>> c.insert(1,5)
>>> print(a)
>>> print(b)
```

(b) [3 points] What is a *statement*? What is an *expression*? How do they differ?

A *statement* is a command to do something. Each line in a function definition should be a statement. An *expression* represents a value. Python will evaluate an expression as part of a command, but it is not a command by itself.

(c) [4 points] What is a *parameter*? What is an *argument*? How are they related?

A *parameter* is a variable in the parentheses at the start of a function definition.
An *argument* is an expression in the parentheses of a function call.
A function call evaluates the arguments and plugs the result into the parameters before executing the function body.

(d) [4 points] Describe how we write a function specification in this class. We are looking for you to identify four important parts of the specification (though not every function specification has all of these parts).

A specification is written as a docstring at the start of the function body.
This docstring starts with a single line summary (which includes the value returned).
This is followed by one or more paragraphs giving more detail about the function.
Each paramater is identified an described in the specification.
Finally, there is a precondition for each parameter, identifying what values it can take.

3. [22 points] **Call Frames.**

Consider the following function definitions.

```
def magnitude(p):
    """Returns: dist to origin
    Precondition: p a list of 2 coords"""
    x = square(p[0])
    y = square(p[1])
    return (x+y) ** 0.5

```

```
def square(x):
    """Returns: square of x"""
    return x*x
```

The function `magnitude` treats a list like a 2-dimensional point and computes its distance from the origin. Assume that `q = [3.0,4.0]` is a global variable referencing a list in heap space, as shown on the next page. On the next two pages, diagram the evolution of the call

`d = magnitude(q)`

Diagram the state of the *entire call stack* for the function `magnitude` when it starts, for each line executed, and when the frame is erased. If any other functions are called, you should do this for them as well (at the appropriate time). This will require a total of **nine** diagrams, not including the (pre-call) diagram shown.

You should draw also the state of global space and heap space at each step. You can ignore the folders for the function definitions. Only draw folders for lists or objects. You are also allowed to write "unchanged" if no changes were made to either global or heap space.

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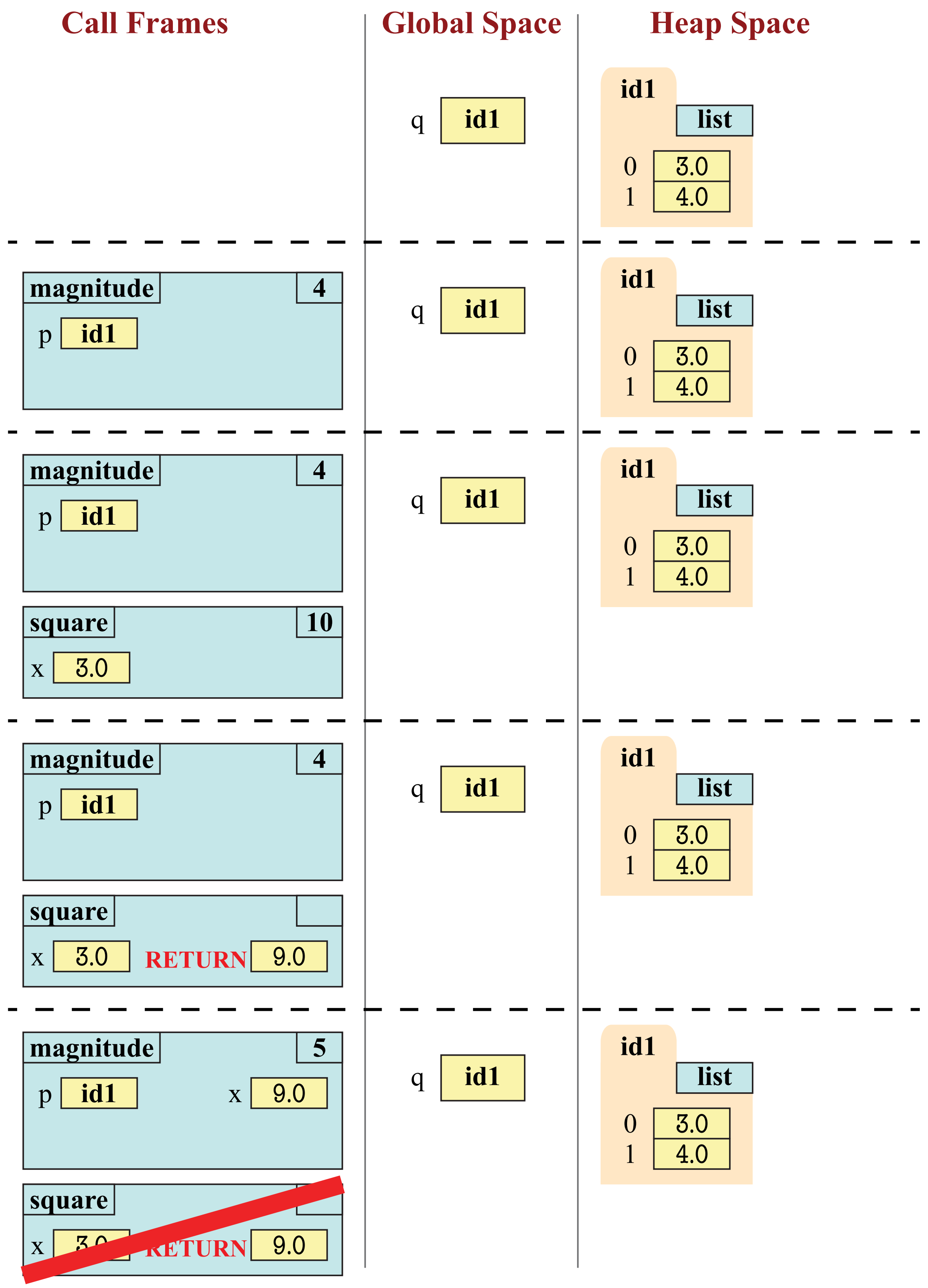
**Hint**: Pay close attention to the line numbers. They are different than those in the assignment.



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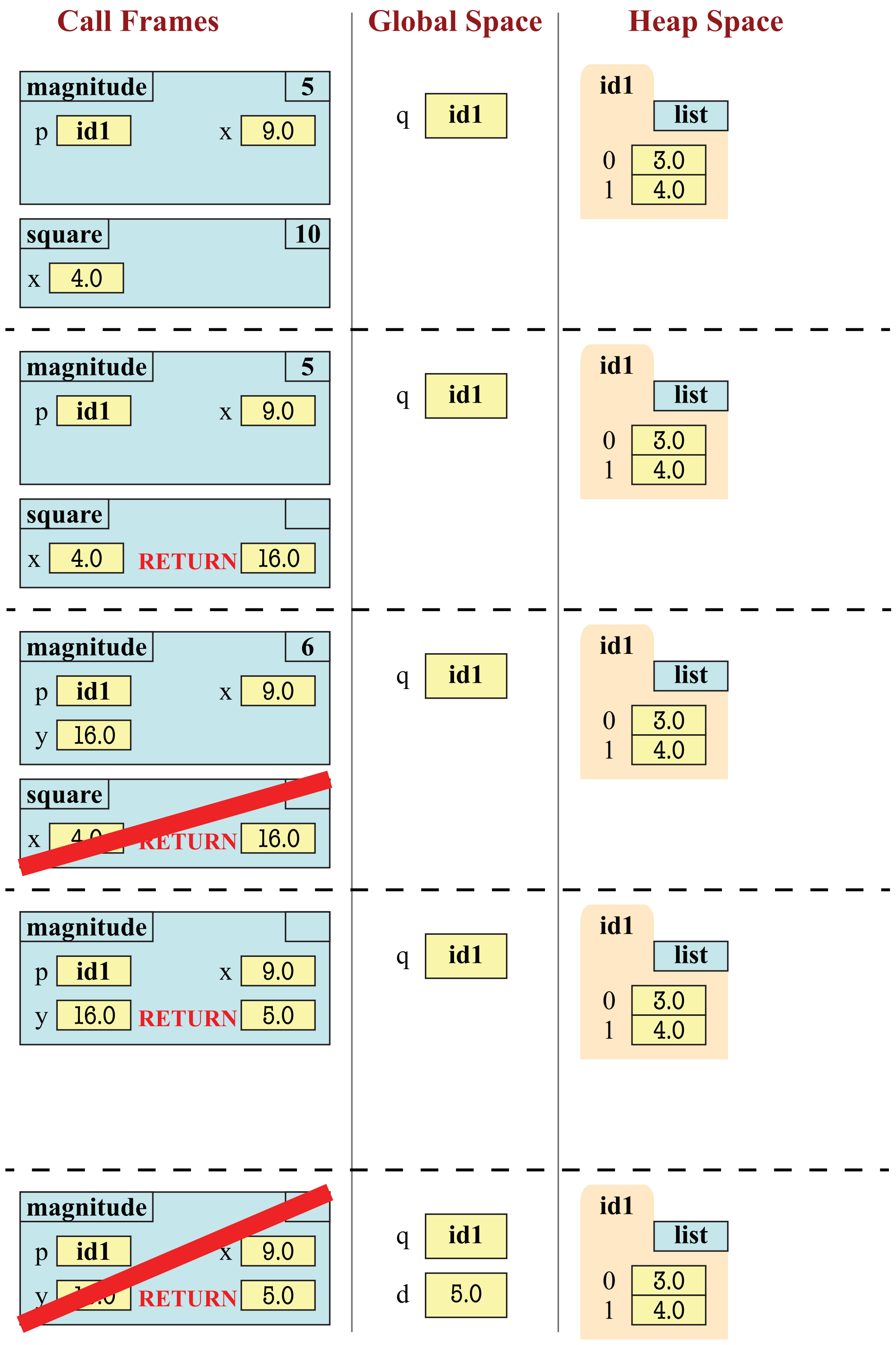

4. [20 points] **String Slicing**.

Recall that a Cornell netid is a string with 2 or 3 initials, followed by an arbitrary number of digits. We not worry about case for netids, so `'wmw2'`, `'WMW2'` and `'Wmw2'` are all the same.

Two netids are called *twins* if they have the same initials, and their numbers only differ by one. So `'wmw2'` and `'wmw3'` are twins, as are `'js209'` and `'JS210'`.

Implement the function below. **You may not use loops**.

```
def twinsies(netid1,netid2):
    """Returns: True if netid1 and netid2 are twins, off by 1; False otherwise.

    Example: twinsies('wmw2','WmW3') is True (case is ignored when comparing)

    Precondition: netid1, netid2 are strings representing net-ids."""
    # Find the letter part
    pos1 = 2
    if netid1[pos1].isalpha():
        pos1 = 3
    pos2 = 2
    if netid1[pos2].isalpha():
        pos2 = 3

    # Compare the letter parts
    pref1 = netid1[:pos1].lower()
    pref2 = netid1[:pos2].lower()
    if pref1 != pref2:
        return False

    # Extract the number part
    fid1 = int(netid1[pos1:])
    fid2 = int(netid2[pos2:])

    # Compare for twins
    return fid1 == fid2+1 or fid1+1 == fid2
```

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5. [22 points total] **Testing and Debugging**.

   (a) [10 points] Consider the following function header and specification:

```
def pairs(s1,s2):
    """Returns: The number of adjacent pairs of s2 inside s1

    Example: pairs('aabaa','a') is 2
             pairs('eeee','e') is 3

    Precondition: s1 is a nonempty string of lower case letters.
    Precondition: s2 is a single lower-case letter."""
```

**Do not implement this function**. Instead, write down a list of at least **five test cases** that you would use to test out this function. By a test case, we just mean an input and an expected output; you do not need to write an `assert_equals` statement. For each test case *explain why it is significantly different from the others.*

There are many different possible answers to this question. Below are the different solutions we were thinking of. If you had (at least) five test cases that were close to the ones below, you got full credit. Otherwise, we checked if your test cases were *different enough*, and awarded you 2 points for each test.

| **Inputs** | | **Output** | **Reason** |
|---|---|---|---|
| s1='bbb' | s2='a' | 0 | String s2 not in s1 |
| s1='aba' | s2='a' | 0 | String s2 in s1, but no adjacent pairs |
| s1='aab' | s2='a' | 1 | Single adjacent pair, character appears twice |
| s1='aaba' | s2='a' | 1 | Single adjacent pair, character appears later |
| s1='aabaa' | s2='a' | 2 | Multiple, non-overlapping adjacent pairs |
| s1='aaaa' | s2='a' | 3 | Multiple, overlapping adjacent pairs |

   (b) [12 points] You worked with the function `pigify` in lab. This function takes a string and converts it into Pig Latin according to the following rules:

   1. The vowels are `'a'`, `'e'`, `'i'`, `'o'`, `'u'`, as well as any `'y'` that is *not* the first letter of a word. All other letters are consonants.
   2. If the English word begins with a vowel, we append `'hay'` to the end of the word to get the Pig Latin equivalent.
   3. If the English word starts with `'q'`, we assume it is followed by `'u'` (this is part of the precondition). We move `'qu'` to the end of the word, and append `'ay'`.
   4. If the English word begins with a consonant, we move all the consonants up to the first vowel (if any) to the end and add `'ay'`.

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Below are implementations of `pigify`, its helper `first_vowel`, as well as a new function, `sentipig`. The function `sentipig` allows us to apply Pig Latin to "sentences". However, for simplicity, we assume that the sentences have all lower case letters and no punctuation. They are really just multiple words separated by spaces.

There are ***at least* four bugs** in the code below. These bugs are across all functions and are not limited to a single function. To help find the bugs, we have added several print statements throughout the code. The result of running the code with these print statements shown on the next page. Using this information as a guide, identify and fix the four bugs on the page after this print-out. You should explain your fixes.

**Hint**: Pay close attention to the specifications. These versions of the functions are slightly different from those you worked with in lab.

```python
def first_vowel(w):
    """Returns: position of the first
    vowel, or len(w) if no vowels.

    Precondition: w is a nonempty string
    with only lowercase letters"""
    minpos = len(w) # no vowels found yet
    vowels = 'aeio'

    for v in vowels:
        print('Looking for '+v)   # Trace
        pos = w.find(v)
        print('Pos is '+str(pos)) # Watch
        if pos != -1 and pos < minpos:
            minpos = pos

    pos = w.find('y')
    print('y Pos is '+str(pos))  # Watch
    if pos != -1 and pos < minpos:
        minpos = pos

    return minpos


def pigify(w):
    """Returns: copy of w in Pig Latin

    Precondition: w a nonempty string
    with only lowercase letters. If w
    starts with 'q', w[1] == 'u'."""
    pos = first_vowel(w)
    if pos == 0:      # Starts w/ vowel
        print('Vowel start')      # Trace
        result = w+'hay'
    elif w[0] == 'q': # Starts with q
        print('Q start')          # Trace
        resalt = w[2:]+'quay'
    else:             # Standard case
        print('Consonant start')  # Trace
        result = w[pos:]+w[:pos]+'ay'

    return result
```

```python


def sentipig(w):
    """Returns: Copy of sentence w with all
    words converted to Pig Latin

    Example: sentipig('barn owl') is
    'arnbay owlhay'

    Precondition: w a string of lower case
    words, each separated by a space"""
    result = ''     # Accumulator
    start = 0       # Start of a word

    for pos in range(len(w)):
        if w[pos] == ' ':
            # Watch
            print('Space at pos '+str(pos))
            word = w[start:pos]
            # Watch
            print('Word is '+repr(word))
            result += pigify(word)+' '
            # Watch
            print('Result is '+repr(result))
            start = pos

    word = w[start:] # Last word
    # Watch
    print('Last word is '+repr(word))
    result += pigify(word)

    return result


# Remaining lines are blank
```

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**Tests**:

```
>>> sentipig('blue')
Last word is 'blue'
Looking for a
Pos is -1
Looking for e
Pos is 3
Looking for i
Pos is -1
Looking for o
Pos is -1
y Pos is -1
Consonant start
ebluay
```

```
>>> sentipig('quick')
Last word is 'quick'
Looking for a
Pos is -1
Looking for e
Pos is -1
Looking for i
Pos is 2
Looking for o
Pos is -1
y Pos is -1
Q start
Traceback (most recent call last):
  File "<stdin>", line 1, in <module>
  File "pigify.py", line 67, in sentipig
    result += pigify(word)
  File "pigify.py", line 42, in pigify
    return result
UnboundLocalError: local variable 'result'
  referenced before assignment
```

```
>>> sentipig('wierd quirk')
Space at pos 5
Word is 'wierd'
Looking for a
Pos is -1
Looking for e
Pos is 2
Looking for i
Pos is 1
Looking for o
Pos is -1
y Pos is -1
Consonant start
Result is 'ierdway '
Last word is ' quirk'
Looking for a
Pos is -1
Looking for e
Pos is -1
Looking for i
Pos is 3
Looking for o
Pos is -1
y Pos is -1
Consonant start
ierdway irk quay
```

```
>>> sentipig('yellow owl')
Space at pos 6
Word is 'yellow'
Looking for a
Pos is -1
Looking for e
Pos is 1
Looking for i
Pos is -1
Looking for o
Pos is 4
y Pos is 0
Vowel start
Result is 'yellowhay '
Last word is ' owl'
Looking for a
Pos is -1
Looking for e
Pos is -1
Looking for i
Pos is -1
Looking for o
Pos is 1
y Pos is -1
Consonant start
yellowhay owl ay
```

**First Bug:**

The bug for the test `sentipig('blue')` is in `first_vowel`. We are missing the vowel `'u'`. To fixe this, Line 8 should be

```
vowels = 'aeiou'
```

**Second Bug:**

The bug for the test `sentipig('quick')` is in `pigify`. Even though the trace shows that we have gone to the correct `elif`, we have misspelled the variable `result`, causing the crash. To fix this, Line 37 should be

```
result = w[2:]+'quay'
```

**Third Bug:**

The bug for `sentipig('duck quack')` is in `sentipig`. When there are multiple words, we are accidentally including the space in the later words. To fix this, Line 67 should be

```
start = pos+1
```

**Fourth Bug:**

The bug for `sentipig('yellow owl')` is in `first_vowel`. This function is treating the first `'y'` as a vowel. To fix this, Line 17 should be

```
pos = w.find('y',1)
```

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6. [20 points] **Objects and Functions**.

Rectangle objects are very common in computer graphics; they are used to indicate a region of pixels on your screen. Rectangles have four attributes with the following invariants.

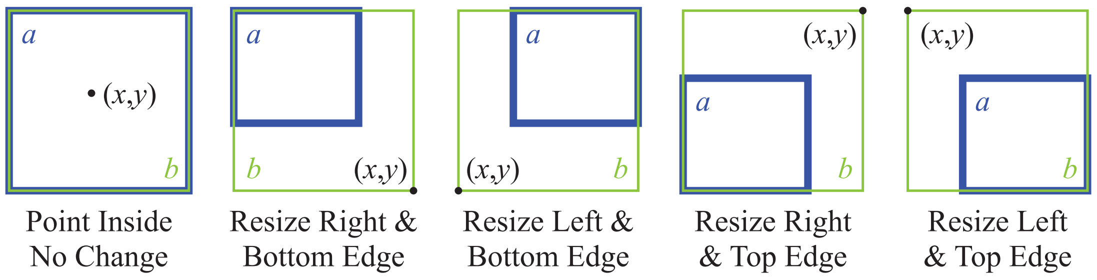
| Attribute | Meaning | Invariant |
|---|---|---|
| `x` | position of left edge | `int` value |
| `y` | position of top edge | `int` value |
| `width` | distance from left to right edge | `int` value >= 0 |
| `height` | distance from top to bottom edge | `int` value >= 0 |

The invariants all specify `int` values because pixel positions are whole numbers. Furthermore, y-coordinates on the screen get larger **downwards**; the origin is the top left corner of the screen.

To make a Rectangle object, call the function `Rectangle(x,y,w,h)` (do not worry about the module), giving the values for the attributes in order. The constructor enforces the object invariants, and will cause an error if you violate them. Note that it is perfectly okay to have a rectangle whose width or height is equal to 0.

Sometimes we want to *expand* a rectangle to include a point. An expansion is the minimal rectangle containing both the original rectangle and the point. This expansion has at least two edges in common with the original rectangle, since we only need to move two edges to the point.

For example, suppose we have a point $(x,y)$ and a rectangle $a$. The illustration below shows how we might expand $a$ to get a new rectangle $b$. In the first picture, the point is inside of the rectangle, so there is nothing to do. In the other cases, we have to resize two edges to meet the point $(x,y)$. These are not the only cases (sometimes we only need to resize one of the two edges), but they are enough to give the idea.



Using the illustration above, implement the function on the next page.

**Hint**. When you write your if-statements, only use just one of `x` or `y` in each if-statement, *not both*. This will make the function a lot simpler and cut down on the number of if-statements. You are also a lot less likely to miss a case this way.

```
def expand(rect,x,y):
    """Expands this rectangle to include the point (x,y).

    This function is a procedure and modifies the object rect.

    Precondition: rect is a Rectangle object. x and y are ints."""
    # Find rectangle edges
    left = rect.x
    rght = rect.x+width
    top  = rect.y
    bot  = rect.y+rect.height

    # Compare the left/right edges
    if x < left:
        left = x
    elif x > rght:
        rght = x

    # Compare the top/bot edges
    if y < top:
        top = y
    elif y > bot:
         bot = y

    # Convert back to rectangle
    rect.x = left
    rect.width = rght-left
    rect.y = top
    rect.height = bot-top
```