Lecture 6

Specifications & Testing
Announcements For This Lecture

Last Call

• Acad. Integrity Quiz
• Take it by tomorrow
• Also remember survey

Assignment 1

• Posted on web page
  ▪ Due Sun, Sep. 17th
  ▪ Due in place of Lab 4
  ▪ Revise until correct
• Can work in pairs
  ▪ One submission for pair
  ▪ **Mixer** Tue 5:30 meeting in Phillips 203
One-on-One Sessions

• Starts today: 1/2-hour one-on-one sessions
  ▪ To help prepare you for the assignment
  ▪ Primarily for students with little experience

• There are still some spots available
  ▪ Sign up for a slot in CMS

• Will keep running after September 17
  ▪ Will open additional slots after the due date
  ▪ Will help students revise Assignment 1
Recall: The Python API

Function

name

math.ceil(x)

Return the ceiling of x, the smallest integer greater than or equal to x.

Possible arguments

Module

What the function evaluates to
Recall: The Python API

<table>
<thead>
<tr>
<th>Function name</th>
<th>Possible arguments</th>
<th>What the function evaluates to</th>
</tr>
</thead>
<tbody>
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<td><code>math.ceil(x)</code></td>
<td></td>
<td>Return the ceiling of x, the smallest integer greater than or equal to x.</td>
</tr>
</tbody>
</table>

- **This is a specification**
  - Enough info to use `func`
  - But not how to implement
- Write them as **docstrings**
def greet(n):
    """Prints a greeting to the name n

    Greeting has format 'Hello <n>!' Followed by conversation starter.

    Parameter n: person to greet
    Precondition: n is a string"
    print('Hello '+'+n+'!')
    print('How are you?')
def greet(n):
    """Prints a greeting to the name n
    Greeting has format 'Hello <n>!' Followed by conversation starter.
    Parameter n: person to greet
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    Parameter n: person to greet
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    print('Hello '+n+'!')
    print('How are you?')
Anatomy of a Specification

```python
def to_centigrade(x):
    """Returns: x converted to centigrade
    Value returned has type float.
    Parameter x: temp in fahrenheit
    Precondition: x is a float"
    return 5*(x-32)/9.0
```

One line description, followed by blank line

More detail about the function. It may be many paragraphs.

Parameter description

Precondition specifies assumptions we make about the arguments
Anatomy of a Specification

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def to_centigrade(x):
    """Returns: x converted to centigrade
    Value returned has type float.
    Parameter x: temp in fahrenheit
    Precondition: x is a float"
    return 5*(x-32)/9.0
```

“Returns” indicates a fruitful function

More detail about the function. It may be many paragraphs.

Parameter description

Precondition specifies assumptions we make about the arguments
Preconditions

• Precondition is a promise
  ▪ If precondition is true, the function works
  ▪ If precondition is false, no guarantees at all

• Get software bugs when
  ▪ Function precondition is not documented properly
  ▪ Function is used in ways that violates precondition

  >>> to_centigrade(32.0)
  0.0

  >>> to_centigrade(212)
  100.0
Preconditions

• Precondition is a promise
  ▪ If precondition is true, the function works
  ▪ If precondition is false, no guarantees at all

• Get software bugs when
  ▪ Function precondition is not documented properly
  ▪ Function is used in ways that violates precondition

>>> to_centigrade(32.0)
0.0

>>> to_centigrade(212)
100.0

>>> to_centigrade('32')
Traceback (most recent call last):
  File "<stdin>", line 1, in <module>
  File "temperature.py", line 19 ...
TypeError: unsupported operand type(s) for -: 'str' and 'int'

Precondition violated
Test Cases: Finding Errors

- **Bug**: Error in a program. (Always expect them!)
- **Debugging**: Process of finding bugs and removing them.
- **Testing**: Process of analyzing, running program, looking for bugs.
- **Test case**: A set of input values, together with the expected output.

Get in the habit of writing test cases for a function from the function’s specification —even *before* writing the function’s body.

```python
def number_vowels(w):
    """Returns: number of vowels in word w.
    ""
    Precondition: w string w/ at least one letter and only letters"
    pass  # nothing here yet!
```

9/7/17 Specifications & Testing 14
Test Cases: Finding Errors

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- **Testing**: Process of analyzing, running program, looking for bugs.
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Get in the habit of writing test cases from the function’s specification — even before writing the function’s body.

```python
def number_vowels(w):
    """Returns: number of vowels in word w.
    """
    # nothing here yet!
```

**Some Test Cases**
- `number_vowels('Bob')`
  - Answer should be 1
- `number_vowels('Aeiuo')`
  - Answer should be 5
- `number_vowels('Grrr')`
  - Answer should be 0
Representative Tests

• Cannot test all inputs
  - “Infinite” possibilities
• Limit ourselves to tests that are representative
  - Each test is a significantly different input
  - Every possible input is similar to one chosen
• An art, not a science
  - If easy, never have bugs
  - Learn with much practice

Representative Tests for number_vowels(w)

• Word with just one vowel
  - For each possible vowel!
• Word with multiple vowels
  - Of the same vowel
  - Of different vowels
• Word with only vowels
• Word with no vowels
How Many “Different” Tests Are Here?

number_vowels(w)

<table>
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<tr>
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<th>OUTPUT</th>
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</thead>
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<tr>
<td>'hat'</td>
<td>1</td>
</tr>
<tr>
<td>'charm'</td>
<td>1</td>
</tr>
<tr>
<td>'bet'</td>
<td>1</td>
</tr>
<tr>
<td>'beet'</td>
<td>2</td>
</tr>
<tr>
<td>'beetle'</td>
<td>3</td>
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A: 2  
B: 3  
C: 4  
D: 5  
E: I do not know
How Many “Different” Tests Are Here?

number_vowels(w)

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- If in doubt, just add more tests
- You are never penalized for too many tests

A: 2 
B: 3  CORRECT(ISH) 
C: 4 
D: 5 
E: I do not know
The following function has a bug:

```python
def last_name_first(n):
    """Returns: copy of <n> but in the form <last-name>, <first-name>
Precondition: <n> is in the form <first-name> <last-name>
with one or more blanks between the two names""
    end_first = n.find(' ')
    first = n[:end_first]
    last = n[end_first+1:]
    return last+', '+first
```

Representative Tests:
- `last_name_first('Walker White')` gives 'White, Walker'
- `last_name_first('Walker White')` gives 'White, Walker'
Running Example

• The following function has a bug:

```python
def last_name_first(n):
    """Returns: copy of <n> but in the form <last-name>, <first-name>
    Precondition: <n> is in the form <first-name> <last-name>
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    end_first = n.find(' ')  
    first = n[:end_first]
    last  = n[end_first+1:]
    return last+', '+first
```

• Representative Tests:
  - last_name_first('Walker White') give 'White, Walker'
  - last_name_first('Walker White') gives 'White, Walker'

Look at precondition when choosing tests
Unit Test: A Special Kind of Script

- Right now to test a function we do the following
  - Start the Python interactive shell
  - Import the module with the function
  - Call the function several times to see if it is okay
- But this is incredibly time consuming!
  - Have to quit Python if we change module
  - Have to retype everything each time
- What if we made a second Python module/script?
  - This module/script tests the first one
Unit Test: A Special Kind of Script

• A unit test is a script that tests another module
  ▪ It imports the other module (so it can access it)
  ▪ It imports the cornell module (for testing)
  ▪ It defines one or more test cases
    • A representative input
    • The expected output

• The test cases use the cornell function

```python
def assert_equals(expected, received):
    """Quit program if expected and received differ"""
```
import name  # The module we want to test
import cornell  # Includes the test procedures

# First test case
result = name.last_name_first('Walker White')
cornell.assert_equals('White, Walker', result)

# Second test case
result = name.last_name_first('Walker White')
cornell.assert_equals('White, Walker', result)

print('Module name is working correctly')
import name   # The module we want to test
import cornell  # Includes the test procedures

# First test case
result = name.last_name_first('Walker White')
cornell.assert_equals('White, Walker', result)

# Second test case
result = name.last_name_first('Walker White')
cornell.assert_equals('White, Walker', result)

print('Module name is working correctly')
Testing last_name_first(n)

```python
import name  # The module we want to test
import cornell  # Includes the test procedures

# First test case
result = name.last_name_first('Walker White')
cornell.assert_equals('White, Walker', result)

# Second test case
result = name.last_name_first('Walker White')
cornell.assert_equals('White, Walker', result)

print('Module name is working correctly')
```

Quits Python if not equal

Message will print out only if no errors.
Using Test Procedures

• In the real world, we have a lot of test cases
  ▪ I wrote 20000+ test cases for a C++ game library
  ▪ You need a way to cleanly organize them
• **Idea:** Put test cases inside another procedure
  ▪ Each function tested gets its own procedure
  ▪ Procedure has test cases for that function
  ▪ Also some print statements (to verify tests work)
• Turn tests on/off by calling the test procedure
def test_last_name_first():
    """Test procedure for last_name_first(n)"""
    print('Testing function last_name_first')
    result = name.last_name_first('Walker White')
    cornell.assert_equals('White, Walker', result)
    result = name.last_name_first('Walker White')
    cornell.assert_equals('White, Walker', result)

    # Execution of the testing code
    test_last_name_first()
    print('Module name is working correctly')
Test Procedure

def test_last_name_first():
    """Test procedure for last_name_first(n)"""
    print('Testing function last_name_first')
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    cornell.assert_equals('White, Walker', result)
    result = name.last_name_first('Walker White')
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# Execution of the testing code
test_last_name_first()
print('Module name is working correctly')