

Lecture 8

Algorithm Design

Announcements For This Lecture

Assignment 1

- Due **TOMORROW**
 - Due *before* midnight
 - Submit something...
 - Last revision Sep. 29
- Grades posted Friday
- Complete the Survey
 - Must answer individually

Getting Help

- Can work on it in lab
 - But still have a new lab
 - Make sure you do both
- Consulting Hours
 - But expect it to be busy
 - First-come, first-served
- One-on-Ones still going
 - Lots of spaces available

What Are Algorithms?

Algorithm

- Step-by-step instructions
 - Not specific to a language
 - Could be a cooking recipe
- **Outline** for a program

Implementation

- Program for an algorithm
 - In a specific language
 - What we often call coding
- The **filled in** outline

- Good programmers can separate the two
 - Work on the algorithm first
 - Implement in language second
- Why approach strings as **search-cut-glue**

Difficulties With Programming

Syntax Errors

- Python can't understand you
- **Examples:**
 - Forgetting a colon
 - Not closing a parens
- Common with beginners
 - But can quickly train out

Conceptual Errors

- Does what you say, not mean
- **Examples:**
 - Forgot last char in slice
 - Used the wrong argument
- Happens to everyone
 - Large part of CS training

Proper algorithm design
reduces **conceptual errors**

Testing First Strategy

- **Write the Tests First**

Could be script or written by hand

- **Take Small Steps**

Do a little at a time; make use of **placeholders**

- **Intersperse Programming and Testing**

When you finish a step, test it immediately

- **Separate Concerns**

Do not move to a new step until current is done

Testing First Strategy

- **Write the Tests First**

Could be script or written by hand

- **Take Small Steps**

Do 2

- **Inter**

When

Will see several strategies.
But all built on this core idea.

ers

- **Separate Concerns**

Do not move to a new step until current is done

Using Placeholders in Design

- **Strategy**: fill in definition a little at a time
- We start with a function *stub*
 - Function that can be called but is unfinished
 - Allows us to test while still working (later)
- All stubs must have a function header
 - But the definition body might be “empty”
 - Certainly is when you get started

A Function Stub

```
def last_name_first(s):
```

```
    """Returns: copy of s in form 'last-name, 'first-name'
```

```
    Precondition: s is in form 'first-name last-name'  
    with one blank between the two names"""
```

```
    # Finish the body
```



“Empty”

But it Cannot Really Be Empty

```
def last_name_first(s):
```

```
| # Finish the body
```



Error

- A function definition is only valid with a body
 - (Single-line) comments do not count as body
 - But doc-strings do count (part of help function)
- So you should always write in the specification

An Alternative: Pass

```
def last_name_first(s):  
    | pass
```



Fine!

- You can make the body non-empty with `pass`
 - It is a command to “do nothing”
 - Only purpose is to ensure there is a body
- You would remove it once you got started

Ideally: Use Both

```
def last_name_first(s):  
    """Returns: copy of s in form 'last-name, 'first-name'  
  
    Precondition: s is in form 'first-name last-name'  
    with one blank between the two names"""  
    pass
```

Now `pass` is a note that is unfinished.
Can leave it there until work is done.

Outlining Your Approach

- Recall the two types of errors you will have
 - **Syntax Errors**: Python can't understand you
 - **Conceptual Errors**: Does what you say, not mean
- To remove conceptual errors, **plan before code**
 - Create outline of the steps to carry out
 - Write in this outline as comments
- This outline is called *pseudocode*
 - English statements of what to do
 - But corresponds to something simple in Python

Example: Reordering a String

```
def last_name_first(s):  
    """Returns: copy of s in form 'last-name, 'first-name'  
  
    Precondition: s is in form 'first-name last-name'  
    with one blank between the two names"""  
  
    # Find the space between the two names  
  
    # Cut out the first name  
  
    # Cut out the last name  
  
    # Glue them together with a comma
```

Example: Reordering a String

```
def last_name_first(s):  
    """Returns: copy of s in form 'last-name, first-name'  
  
    Precondition: s is in form 'first-name last-name'  
    with one blank between the two names"""  
    end_first = s.find(' ')  
  
    # Cut out the first name  
    # Cut out the last name  
    # Glue them together with a comma
```

Example: Reordering a String

```
def last_name_first(s):  
    """Returns: copy of s in form 'last-name, first-name'  
  
    Precondition: s is in form 'first-name last-name'  
    with one blank between the two names"""  
    end_first = s.find(' ')  
    first_name = s[:end_first]  
  
    # Cut out the last name  
  
    # Glue them together with a comma
```

What is the Challenge?

- Pseudocode must correspond to Python
 - Preferably implementable in one line
 - **Unhelpful:** # Return the correct answer
- So what can we do?
 - Depends on the types involved
 - Different types have different operations
 - You should memorize important operations
 - Use these as **building blocks**

Case Study: Strings

- We can **slice** strings (`s[a:b]`)
- We can **glue** together strings (+)
- We have a lot of string **methods**
 - We can **search** for characters
 - We can **count** the number of characters
 - We can **pad** strings
 - We can **strip** padding
- Sometimes, we can **cast** to a new type

Early Testing

- **Recall:** Combine programming & testing
 - After each step we should test
 - But it is unfinished; answer is incorrect!
- **Goal:** ensure *intermediate results* expected
 - Take an input from your testing plan
 - Call the function on that input
 - Look at the results at each step
 - Make sure they are what you expect
- Add a **temporary return value**

Stubbed Returns

```
def last_name_first(s):  
    """Returns: copy of s in form 'last-name, first-name'  
  
    Precondition: s is in form 'first-name last-name'  
    with one blank between the two names"""  
    end_first = s.find(' ')  
    first = s[:end_first]  
  
    # Cut out the last name  
    # Glue them together with a comma  
    return first      # Not the final answer
```

Working with Helpers

- Suppose you are unsure of a step
 - You maybe have an idea for **pseudocode**
 - But not sure if it easily converts to Python
- But you can **specify** what you want
 - Specification means a **new function!**
 - Create a specification stub for that function
 - Put a call to it in the original function
- Now can **lazily** implement that function

Example: last_name_first

```
def last_name_first(s):  
    """Returns: copy of s in the form  
    'last-name, first-name'  
    Precondition: s is in the form  
    'first-name last-name' with  
    with one blank between names"""  
    # Cut out the first name  
    # Cut out the last name  
    # Glue together with comma  
    # Return the result
```

Example: last_name_first

```
def last_name_first(s):  
    """Returns: copy of s in the form  
    'last-name, first-name'  
    Precondition: s is in the form  
    'first-name last-name' with  
    with one blank between names"""  
    first = first_name(s)  
    # Cut out the last name  
    # Glue together with comma  
    return first # Stub
```

```
def first_name(s):  
    """Returns: first name in s  
    Precondition: s is in the form  
    'first-name last-name' with  
    one blank between names"""  
    pass
```

Example: last_name_first

```
def last_name_first(s):  
    """Returns: copy of s in the form  
    'last-name, first-name'  
    Precondition: s is in the form  
    'first-name last-name' with  
    with one blank between names"""  
    first = first_name(s)  
    # Cut out the last name  
    # Glue together with comma  
    return first # Stub
```

```
def first_name(s):  
    """Returns: first name in s  
    Precondition: s is in the form  
    'first-name last-name' with  
    one blank between names"""  
    end = s.find(' ')  
    return s[:end]
```

Concept of Top Down Design

- Function specification is **given** to you
 - This cannot change at all
 - Otherwise, you break the team
- But you **break it up** into little problems
 - Each naturally its own function
 - YOU design the specification for each
 - Implement and test each one
- Complete before the main function

Testing and Top Down Design

```
def test_first_name():
```

```
    """Test procedure for first_name(n)"""
```

```
    result = name.first_name('Walker White')
```

```
    introcs.assert_equals('Walker', result)
```

```
def test_last_name_first():
```

```
    """Test procedure for last_name_first(n)"""
```

```
    result = name.last_name_first('Walker White')
```

```
    introcs.assert_equals('White, Walker', result)
```

A Word of Warning

- **Do not go overboard** with this technique
 - Do not want a lot of one line functions
 - Can make code harder to read in extreme
- Do it if the **code is too long**
 - I personally have a one page rule
 - If more than that, turn part into a function
- Do it if you are **repeating yourself a lot**
 - If you see the same code over and over
 - Replace that code with a single function call

Exercise: Anglicizing an Integer

- `anglicize(1)` is “one”
- `anglicize(15)` is “fifteen”
- `anglicize(123)` is “one hundred twenty three”
- `anglicize(10570)` is “ten thousand five hundred

```
def anglicize(n):
```

```
    """Returns: the anglicization of int n.
```

```
    Precondition: 0 < n < 1,000,000"""
```

```
    pass # ???
```

Exercise: Anglicizing an Integer

```
def anglicize(n):
```

```
    """Returns: the anglicization of int n.
```

```
    Precondition: 0 < n < 1,000,000"""
```

```
    # if < 1000, provide an answer
```

```
    # if > 1000, break into hundreds, thousands parts
```

```
        # use the < 1000 answer for each part , and glue
```

```
        # together with "thousands" in between
```

```
    # return the result
```

Exercise: Anglicizing an Integer

```
def anglicize(n):  
    """Returns: the anglicization of int n.  
    Precondition: 0 < n < 1,000,000"""  
    if n < 1000:          # no thousands place  
        | return anglicize1000(n)  
    elif n % 1000 == 0:  # no hundreds, only thousands  
        | return anglicize1000(n/1000) + ' thousand'  
    else:                # mix the two  
        | return (anglicize1000(n/1000) + ' thousand '+  
                  anglicize1000(n))
```

Exercise: Anglicizing an Integer

```
def anglicize(n):
```

```
    """Returns: the anglicized version of the integer n.  
    Precondition: 0 < n < 1000000000
```

```
    """
```

```
    if n < 1000: # no thousands place
```

```
        | return anglicize1000(n)
```

```
    elif n % 1000 == 0: # no hundreds, only thousands
```

```
        | return anglicize1000(n/1000) + 'thousand'
```

```
    else: # mix the two
```

```
        | return (anglicize1000(n/1000) + 'thousand '+  
                | anglicize1000(n))
```

Now implement this.

See `anglicize.py`