

Lecture 9

Algorithm Design

Announcements for Today

Assignment 1

- We have finished grading!
 - Resubmit until correct
- If you were **close**...
 - Will get feedback in CMS
 - Fix your assignment
- If you were very **wrong**...
 - You got an e-mail
 - Holding 1-on-1s this week
- **FINISH THE SURVEY**

Reading

- Read Chapter 4
- No reading for Thursday

More Assignments

- A2 extended to **Sunday**
- A3 posted on Monday
 - Due 2 weeks from Fri
 - Before leave for Fall Break

Algorithms: Heart of Computer Science

- **Algorithm**: A step-by-step procedure for how to do something (usually a calculation).
- **Implementation**: How to write an algorithm in a specific programming language
- Good programmers know how to separate the two
 - Work out algorithm on paper or in head
 - Once done, implement it in the language
 - Limits errors to **syntax errors** (easy to find), not **conceptual errors** (much, much harder to find)
- Key to designing algorithms: **stepwise refinement**

Algorithms: Heart of Computer Science

- **Algorithm:** A step-by-step procedure for how to do something (usually a calculation).
- **Implementation:** How to write an algorithm in a specific programming language

Python does what you say, not what you meant

Python cannot "understand" you

- **Implementation:** How to write an algorithm in a specific programming language
 - If you know how to do it, implement it in the language
 - Limits errors to **syntax errors** (easy to find), not **conceptual errors** (much, much harder to find)
- Key to designing algorithms: **stepwise refinement**

Stepwise Refinement: Basic Principles

- **Write Specifications First**

Write a function specification before writing its body

- **Take Small Steps**

Do a little at a time; follow the **Mañana Principle**

- **Run as Often as You Can**

This can catch syntax errors

- **Separate Concerns**

Focus on one step at a time

- **Intersperse Programming and Testing**

When you finish a step, test it immediately

Mañana Principle

- If not in current step, delay to “tomorrow”
 - Use **comments** to write steps in English
 - Add “**stubs**” to allow you to run program often
 - Slowly replace stubs/comments with real code
- Only create new local variables if you have to
- Sometimes results in creation of more functions
 - Replace the step with a function call
 - But leave the *function definition* empty for now
 - This is called **top-down design**

Function Stubs

Procedure Stubs

- Single statement: `pass`
 - Body cannot be empty
 - This command does nothing

- **Example:**

```
def foo():  
    pass
```

Fruitful Stubs

- Single return statement
 - Type should match spec.
 - Return a “default value”

- **Example:**

```
def first_four_letters(s):  
    return '' # empty string
```

Purpose of Stubs

Create a program that may not be correct, but does not crash.

Example: Reordering a String

- `last_name_first('Walker White')` is `'White, Walker'`

```
def last_name_first(s):  
    """Returns: copy of s in form <last-name>, <first-name>  
  
    Precondition: s is in the form <first-name> <last-name>  
    with one blank between the two names"""  
  
    # Find the first name  
  
    # Find the last name  
  
    # Put them together with a comma  
  
    return ' ' # Currently a stub
```


Example: Reordering a String

- `last_name_first('Walker White')` is `'White, Walker'`

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

Refinement: Creating Helper Functions

```
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)  
    # Find the last name  
    # Put 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]
```

Refinement: Creating Helper Functions

```
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)  
    # Find the last name  
    # Put 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]
```

Do This Sparingly

- If you might use this step in **another** function later
- If implementation is rather long and complicated

Example: Reordering a String

- `last_name_first('Walker White')` is `'White, Walker'`

```
def last_name_first(s):  
    """Returns: copy of s in form <last-name>, <first-name>  
    Precondition: s is in the form <first-name> <last-name>  
    with one or more blanks between the two names"""  
    # Find the first name  
    # Find the last name  
    # Put them together with a comma  
    return ' ' # Currently a stub
```

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 "" # empty string
```

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 form of the integer n"""
```

```
    Precondition: 0 < n < 1000000
```

Now implement this.
See anglicize.py

```
    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))
```