Lecture 8

Conditionals & Control Flow

Announcements For This Lecture

Readings

- Sections 5.1-5.7 today
- Chapter 4 for Tuesday

Assignment 2

- Posted **Today**
  - Written assignment
  - Do while revising A1

Assignment 1

- Due **TONIGHT**
  - Due *before* midnight
  - Submit something…
  - Can resubmit to Sep. 28
- Grades posted Saturday
- Complete the Survey
  - Must answer individually

Testing last_name_first(n)

```
# test procedure
def test_last_name_first():
    """Test procedure for last_name_first(n)"""
    result = name.last_name_first('Walker White')
    cornelltest.assert_equals('White, Walker', result)
    result = name.last_name_first('Walker          White')
    cornelltest.assert_equals('White, Walker', result)
```

Call function on test input

Compare to expected output

```
# Application code
if __name__ == '__main__':
    test_last_name_first()
    print 'Module name is working correctly'
```

Test code is properly formatted as script

Types of Testing

Black Box Testing

- Function is "opaque"
  - Test looks at what it does
  - **Fruitful**: what it returns
  - **Procedure**: what changes
- **Example**: Unit tests
- **Problems**:
  - Are the tests everything?
  - What caused the error?

White Box Testing

- Function is "transparent"
  - Tests/debugging takes place inside of function
  - Focuses on where error is
- **Example**: Use of `print`
- **Problems**:
  - Much harder to do
  - Must remove when done

Finding the Error

- Unit tests cannot find the source of an error
- Idea: "Visualize" the program with print statements

```
def last_name_first(n):
    """Returns: copy of <n> in form <last>, <first>"""
    end_first = n.find(' ')
    print end_first
    first = n[:end_first]
    print 'first is '+str(first)
    last  = n[end_first+1:]
    print 'last is '+str(last)
    return last+', '+first
```

Print variable after each assignment

Optional: Annotate value to make it easier to identify

Structure vs. Flow

Program Structure

- Way statements are presented
  - Order statements are listed
  - Inside/outside of a function
  - Will see other ways…
- Indicate possibilities over **multiple executions**

Program Flow

- Order statements are executed
  - Not the same as structure
  - Some statements duplicated
  - Some statements are skipped
- Indicates what really happens in a **single execution**

Have already seen this difference with functions

Structure vs. Flow: Example

Program Structure

```
def foo():
    print 'Hello'

# Script Code
if __name__ == 'main':
    foo()
    foo()
    foo()
```

Statement listed once

Program Flow

```
>>> python foo.py
'Hello'
'Hello'
'Hello'
```

Statement executed 3x

Bugs can occur when we get a flow other than one that we where expecting

Conditionals: If-Statements

Format

```
if <boolean-expression>:
        <statement>
        …
        <statement>
```

Example

```
# Put x in z if it is positive
if x > 0:
    z = x
```

Execution:

if <*boolean-expression*> is true, then execute all of the statements indented directly underneath (until first non-indented statement)

Conditionals: If-Else-Statements

Format	Example

```
if <boolean-expression>:
        <statement>
        …
else:
        <statement>
        …
```

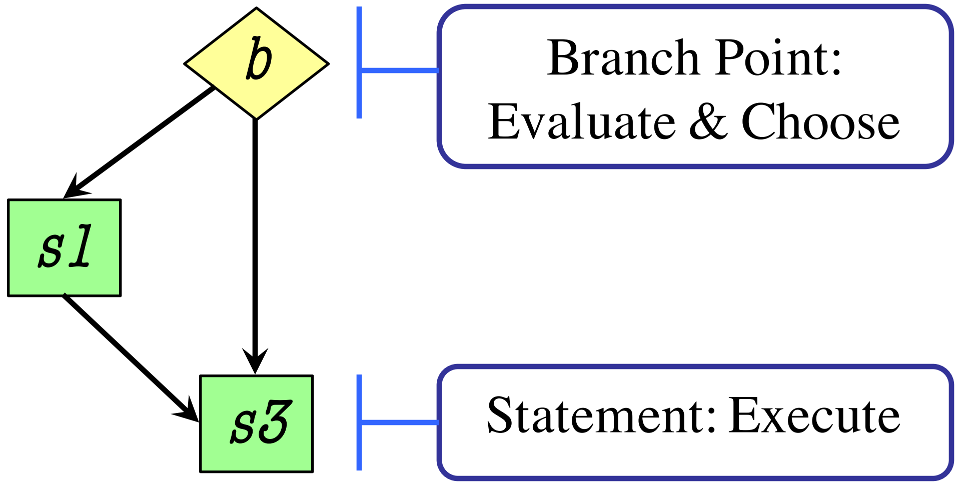
```
# Put max of x, y in z
if x > y:
    z  = x
else:
    z  = y
```

Execution:

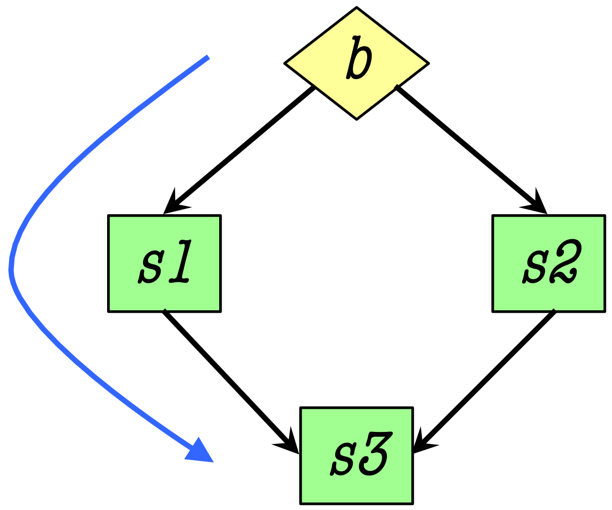
if <*boolean-expression*> is true, then execute statements indented under if; otherwise execute the statements indented under elsec

Conditionals: “Control Flow” Statements

```
if b :
    s1 # statement
s3
```



```
if b :
    s1
else:
    s2
s3
```



Flow

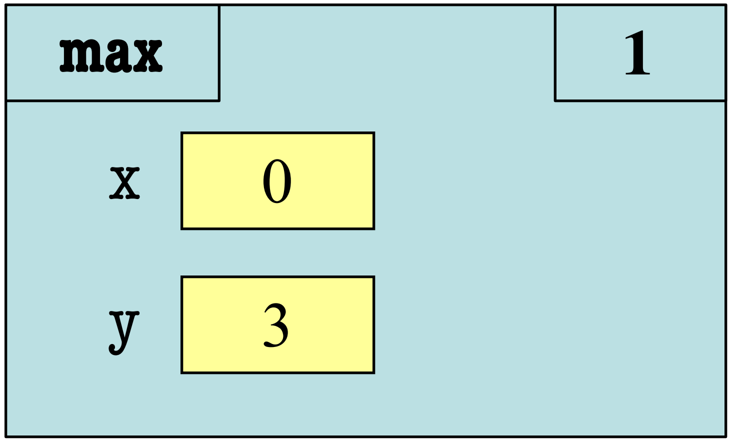
Program only takes one path each execution

Program Flow and Call Frames

```
def max(x,y):
    """Returns: max of x, y"""
    # simple implementation
1   if x > y:
2       return x
3   return y
```

Frame sequence depends on flow

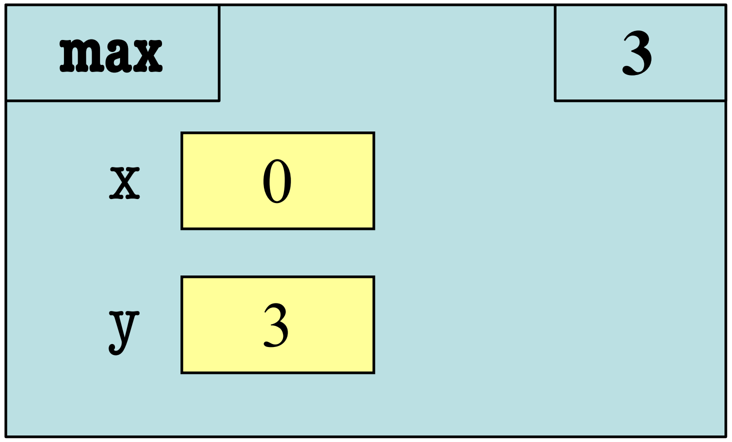
max(0,3):



Program Flow and Call Frames

```
  def max(x,y):
      """Returns: max of x, y"""
      # simple implementation
1     if x > y:
2         return x
3     return y
```

max(0,3):



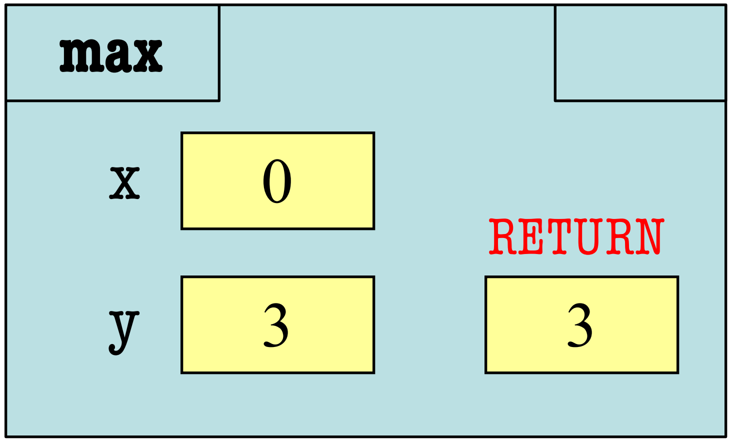
Frame sequence depends on flow

Skips line 2

Program Flow and Call Frames

```
  def max(x,y):
      """Returns: max of x, y"""
      # simple implementation
1     if x > y:
2         return x
3     return y
```

max(0,3):



Frame sequence depends on flow

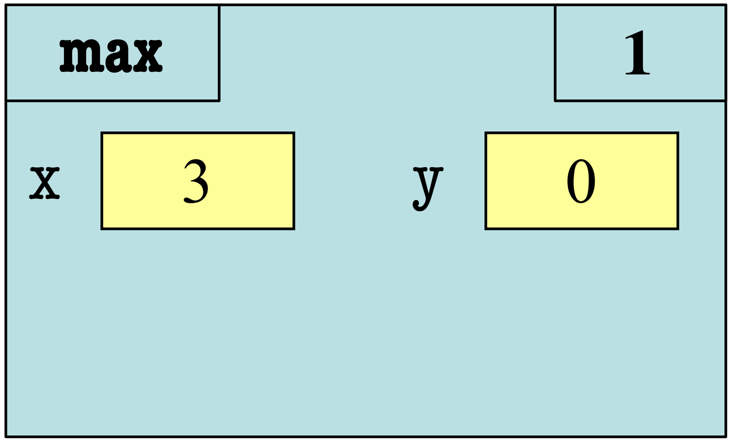
Skips line 2

Program Flow vs. Local Variables

```
  def max(x,y):
      """Returns: max of x, y"""
      # swap x, y
      # put the larger in y
1     if x > y:
2         temp = x
3         x = y
4         y = temp

5     return y
```

- temp is needed for swap
  - x = y loses value of x
  - "Scratch computation"
  - Primary role of local vars
- max(3,0):

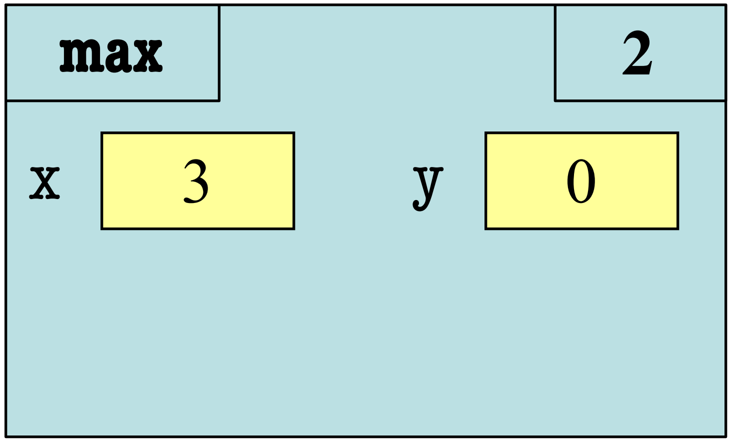


Program Flow vs. Local Variables

```
  def max(x,y):
      """Returns: max of x, y"""
      # swap x, y
      # put the larger in y
1     if x > y:
2         temp = x
3         x = y
4         y = temp

5     return y
```

- temp is needed for swap
  - x = y loses value of **x**
  - “Scratch computation”
  - Primary role of local vars
- max(3,0):

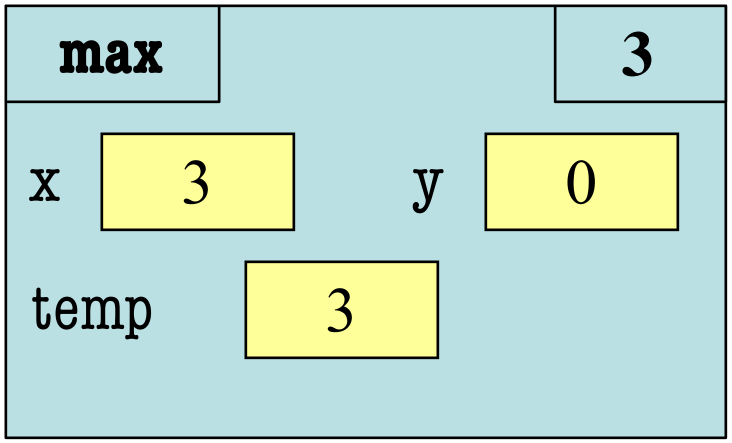


Program Flow vs. Local Variables

```
  def max(x,y):
      """Returns: max of x, y"""
      # swap x, y
      # put the larger in y
1     if x > y:
2         temp = x
3         x = y
4         y = temp

5     return y
```

- temp is needed for swap
  - x = y loses value of x
  - "Scratch computation"
  - Primary role of local vars
- max(3,0):

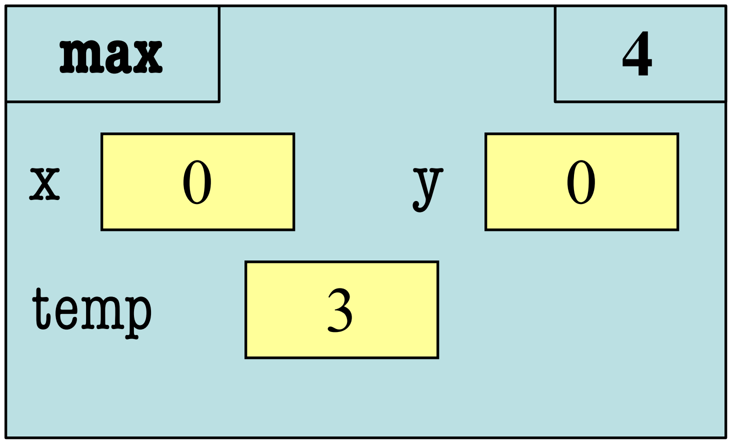


Program Flow vs. Local Variables

```
  def max(x,y):
      """Returns: max of x, y"""
      # swap x, y
      # put the larger in y
1     if x > y:
2         temp = x
3         x = y
4         y = temp

5     return y
```

- temp is needed for swap
  - x = y loses value of x
  - "Scratch computation"
  - Primary role of local vars
- max(3,0):

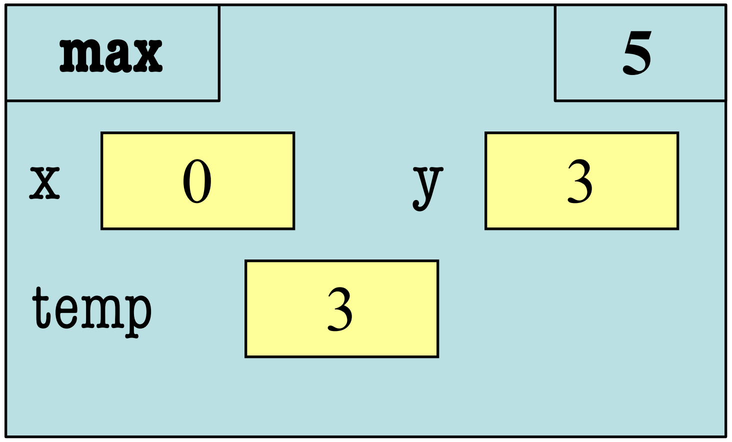


Program Flow vs. Local Variables

```
  def max(x,y):
      """Returns: max of x, y"""
      # swap x, y
      # put the larger in y
1     if x > y:
2         temp = x
3         x = y
4         y = temp

5     return y
```

- temp is needed for swap
  - x = y loses value of x
  - "Scratch computation"
  - Primary role of local vars
- max(3,0):

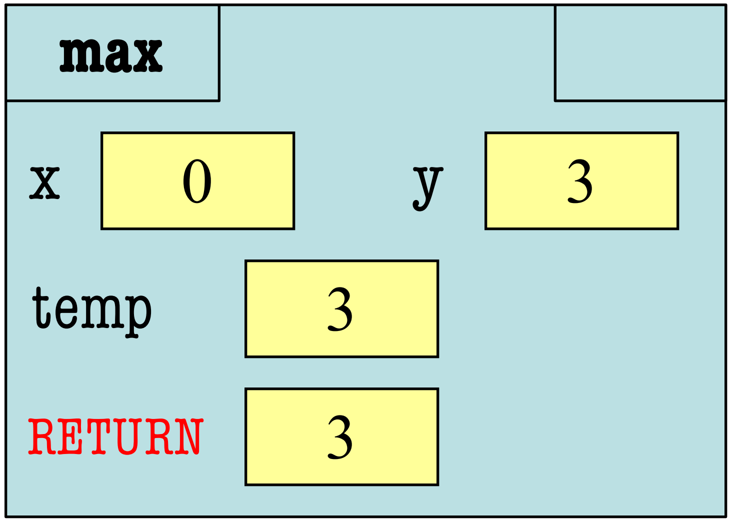


Program Flow vs. Local Variables

```
def max(x,y):
    """Returns: max of x, y"""
    # swap x, y
    # put the larger in y
    if x > y:
        temp = x
        x = y
        y = temp

    return y
```

- temp is needed for swap
  - x = y loses value of x
  - "Scratch computation"
  - Primary role of local vars
- max(3,0):



Program Flow vs. Local Variables

```
def max(x,y):
    """Returns: max of x, y"""
    # swap x, y
    # put the larger in y
    if x > y:
        temp = x
        x = y
        y = temp

    return temp
```

- Value of max(3,0)?

A: 3
B: 0
C: **Error!**
D: I do not know

Program Flow vs. Local Variables

```
def max(x,y):
    """Returns: max of x, y"""
    # swap x, y
    # put the larger in y
    if x > y:
        temp = x
        x = y
        y = temp

    return temp
```

- Value of max(3,0)?

  A: 3 **CORRECT**
  B: 0
  C: **Error!**
  D: I do not know

- Local variables last until
  - They are deleted or
  - End of the function
- Even if defined inside **if**

Program Flow vs. Local Variables

```
def max(x,y):
    """Returns: max of x, y"""
    # swap x, y
    # put the larger in y
    if x > y:
        temp = x
        x = y
        y = temp

    return temp
```

- Value of max(0,3)?

A: 3
B: 0
C: **Error!**
D: I do not know

Program Flow vs. Local Variables

```
def max(x,y):
    """Returns: max of x, y"""
    # swap x, y
    # put the larger in y
    if x > y:
        temp = x
        x = y
        y = temp

    return temp
```

- Value of max(0,3)?

A: 3
B: 0
C: **Error!** **CORRECT**
D: I do not know

- Variable existence depends on flow
- Understanding flow is important in testing

Program Flow and Testing

- Must understand which flow caused the error
  - Unit test produces error
  - Visualization tools show the current flow for error
- Visualization tools?
  - `print` statements
  - Advanced tools in IDEs (Integrated Dev. Environ.)

```
# Put max of x, y in z
print 'before if'
if x > y:
    print 'if x>y'
    z = x
else:
    print 'else x>y'
    z = y
print 'after if'
```

Program Flow and Testing

- Call these tools **traces**
- No requirements on how to implement your traces
  - Less print statements ok
  - Do not need to word them exactly like we do
  - Do what ever is easiest for you to see the flow
- **Example**: flow.py

```
# Put max of x, y in z
print 'before if'
if x > y:
    print 'if x>y'
    z = x
else:
    print 'else x<=y'
    z = y
print 'after if'
```

Traces

Watches vs. Traces

Watch	Trace
• Visualization tool (e.g. print statement)	• Visualization tool (e.g. print statement)
• Looks at **variable value**	• Looks at **program flow**
• Often after an assignment	• Before/after any point where flow can change
• What you did in lab	

Traces and Functions

```
def cycle_left(p):
    print 'Start cycle_left()'
    p.x = p.y
    print p.x
    p.y = p.z
    print p.y
    p.z = p.x
    print p.z
    print 'End cycle_left()'
```

Example: flow.py

Watches

Traces

Local Variables Revisited

- Never refer to a variable that might not exist
- Variable "scope"
  - Block (indented group) where it was first assigned
  - Way to think of variables; not actually part of Python
- **Rule of Thumb**: Limit variable usage to its scope

```
def max(x,y):
    """Returns: max of x, y"""
    # swap x, y
    # put larger in temp
    if x > y:
        temp = x
        x = y
        y = temp

    return temp
```

First assigned

Outside scope

Local Variables Revisited

- Never refer to a variable that might not exist
- Variable "scope"
  - Block (indented group) where it was first assigned
  - Way to think of variables; not actually part of Python
- **Rule of Thumb**: Limit variable usage to its scope

```
def max(x,y):
    """Returns: max of x, y"""
    # swap x, y
    # put larger in temp
    temp = y
    if x > y:
        temp = x

    return temp
```

First assigned

Inside scope

Variation on max

```
def max(x,y):
    """Returns:
        max of x, y"""
    if x > y:
        return x
    else:
        return y
```

Which is better?
Matter of preference

There are two **returns**!
But only one is executed

Conditionals: If-Elif-Else-Statements

Format

```
if <boolean-expression>:
        <statement>
        …
elif <boolean-expression>:
        <statement>
        …
…
else:
        <statement>
        …
```

Example

```
# Put max of x, y, z in w
if x > y and x > z:
    w = x
elif y > z:
    w = y
else:
    w = z
```

Conditionals: If-Elif-Else-Statements

Format

```
if <boolean-expression>:
    <statement>
    …
elif <boolean-expression>:
    <statement>
    …
…
else:
    <statement>
    …
```

Notes on Use

- No limit on number of elif
  - Can have as many as want
  - Must be between if, else
- The else is always optional
  - if-elif by itself is fine
- Booleans checked in order
  - Once it finds a true one, it skips over all the others
  - else means **all** are false

Conditional Expressions

Format

`e1` **`if`** `bexp` **`else`** `e2`

- `e1` and `e2` are any expression
- `bexp` is a boolean expression
- This is an expression!

Example

```
# Put max of x, y in z
```

$$z = \underbrace{x \textbf{ if } x > y \textbf{ else } y}_{\boxed{\text{expression, not statement}}}$$