Lecture 7

Conditionals & Control Flow

Announcements For This Lecture

Assignment 1

- Should be working on it
  - Have covered everything
  - Look at **lab** for more help
- Due Wednesday at mid.
  - Can work at it during lab
  - But labs are due as normal
- One-on-Ones ongoing
  - Lots of spaces available

Partners

- **You** must pair in CMS
- Go into the submission
  - Request your partner
  - Other person accepts

AI Quiz

- Sent out several e-mails
- Will start dropping today

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')
    cornell.assert_equals('White, Walker', result)
    result = name.last_name_first('Walker             White')
    cornell.assert_equals('White, Walker', result)

# Script code
test_last_name_first()
print('Module name passed all tests.')
```

Call function on test input

Compare to expected output

Call test procedure to activate the test

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

Types of Testing

Black Box Testing

- Function is “opaque”
  - Test looks at what it does
  - rns
  - nges
- **Ex**
- **Problems**:
  - Are the tests everything?
  - What caused the error?

Works on functions you did not define

White Box Testing

- Function is “transparent”
  - Tests/debugging takes
  - on
  - or is
- **Ex** nt
- **Problems**:
  - Much harder to do
  - Must remove when done

Can actually find the bug in function

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-name, first-name' """
    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

How to Use the Results

- Goal of **white box testing** is **error location**
  - Want to identify the **exact line** with the error
  - Then you look real hard at line to find error
  - What you are doing in lab this week
- But similar approach to **black box testing**
  - At each line you have **expected** print result
  - Compare it to the **received** print result
  - Line before first mistake is *likely* the error

Warning About Print Statements

- Must remove them when you are done
  - Not part of the specification (violation)
  - Slow everything down unnecessarily
  - **App Store** will reject an app with prints
- But you might want them again later
  - **Solution**: "comment them out"
  - You can always uncomment later

Structure vs. Flow

Program Structure

- Order code is **presented**
  - Order statements are listed
  - Inside/outside of function
  - Will see other ways…
- Defines possibilities over **multiple executions**

Program Flow

- Order code is **executed**
  - Not the same as structure
  - Some statements duplicated
  - Some statements skipped
- Defines what happens in a **single execution**

Have already seen this difference with functions

Structure vs. Flow: Example

Program Structure

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

# Script Code
foo()
foo()
foo()
```

Statement listed once

Program Flow

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

Statement executed 3x

Bugs occur when flow does not **match** expectations

Conditionals: If-Statements

Format

```
if expression :
        statement
        …
        statement
```

Indent

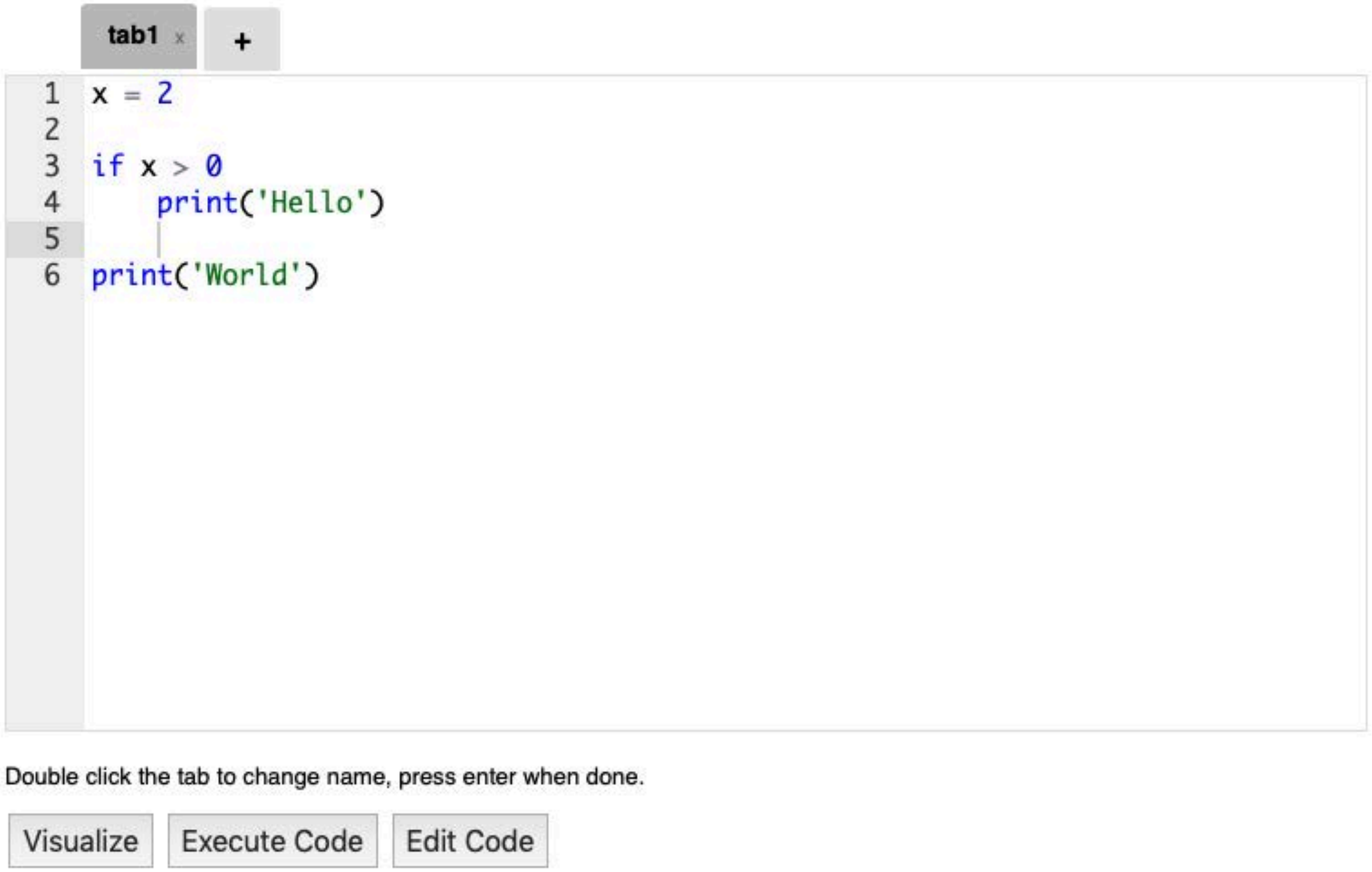
Example

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

Execution:

If *expression* is **True**, execute all statements **indented** underneath

Python Tutor Example



```
x = 2

if x > 0
    print('Hello')

print('World')
```

Double click the tab to change name, press enter when done.

Conditionals: If-Else-Statements

Format

```
if expression :
        statement
        …
else:
        statement
        …
```

Example

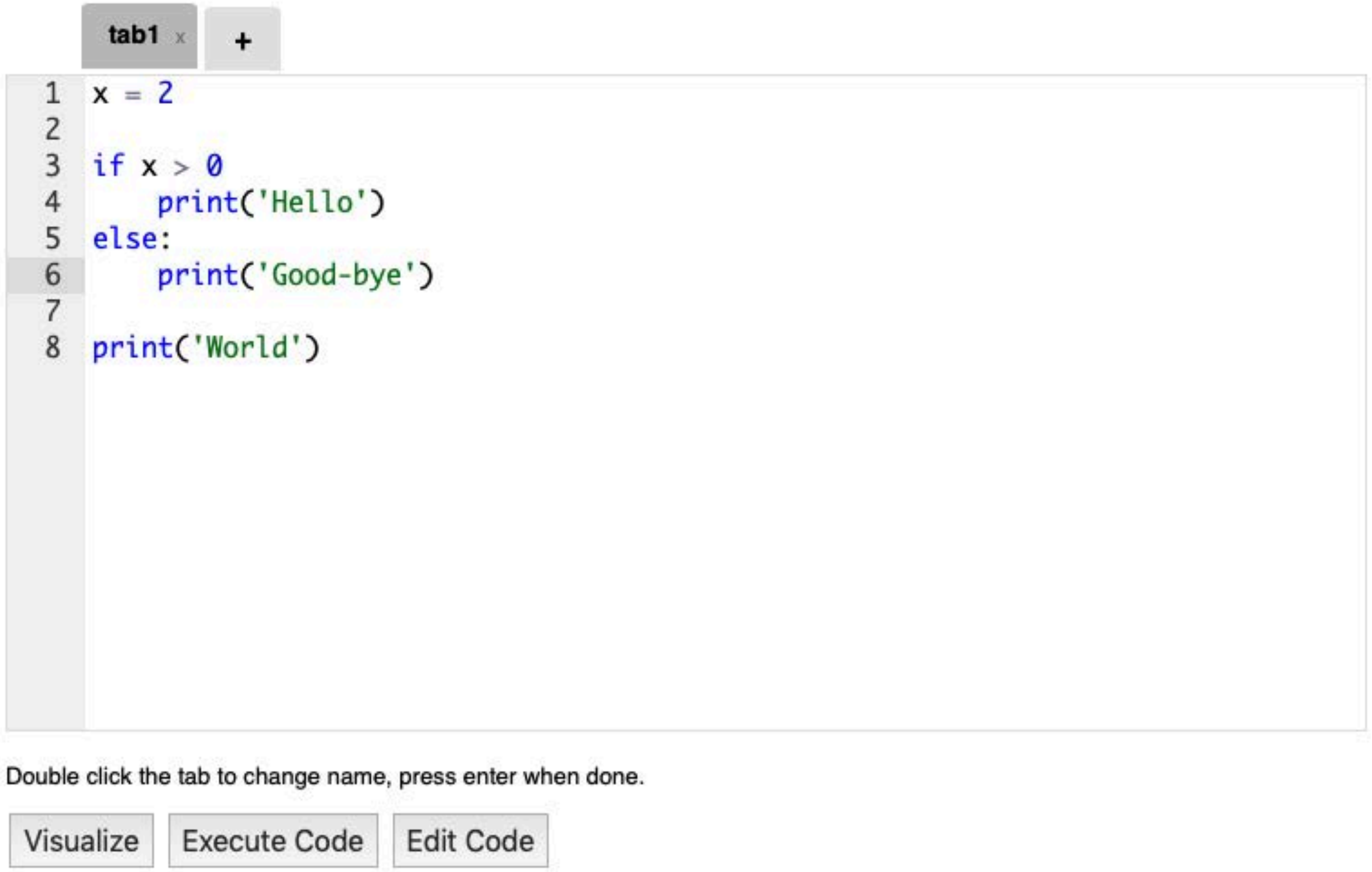
```
# Put max of x, y in z
if x > y:
    z = x
else:
    z = y
```

Execution:

If *expression* is **True**, execute all statements indented under if.

If *expression* is **False**, execute all statements indented under else.

Python Tutor Example



```
x = 2

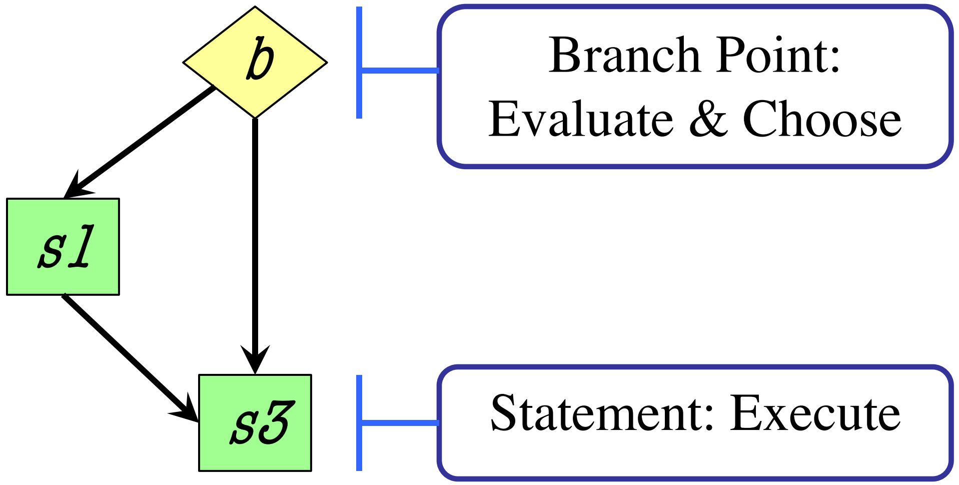
if x > 0
    print('Hello')
else:
    print('Good-bye')

print('World')
```

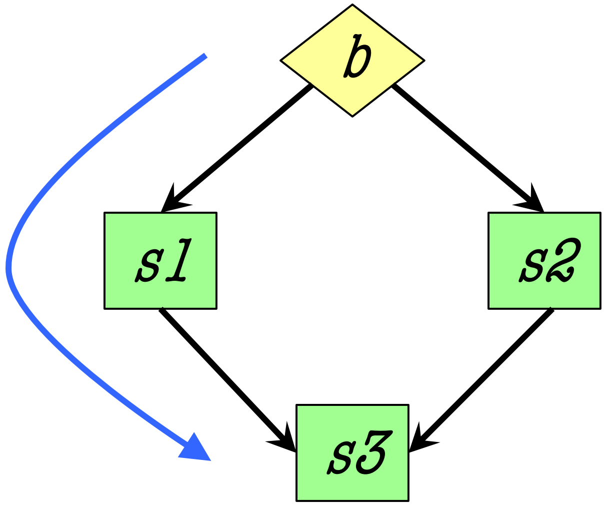
Double click the tab to change name, press enter when done.

Conditionals: “Control Flow” Statements

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



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



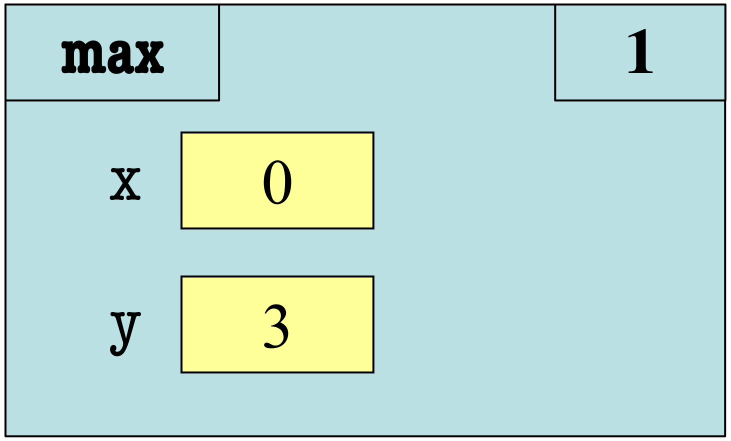
Flow

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
```

max(0,3):



Frame sequence depends on flow

Program Flow and Call Frames

```
  def max(x,y):
      """Returns: max of x, y"""
      # simple implementation
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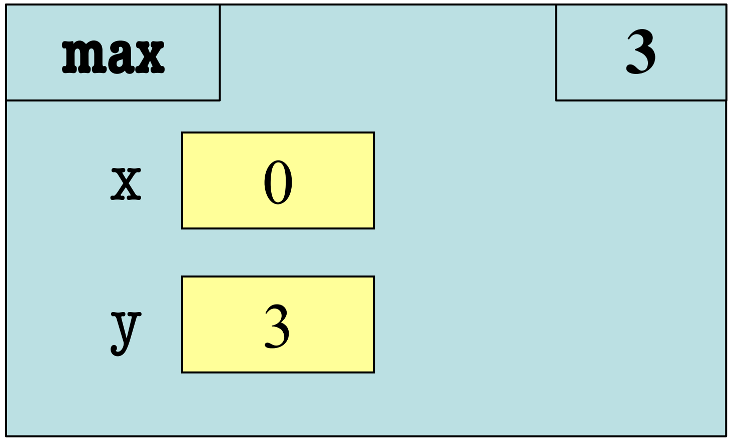
```

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"""
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1     if x > y:
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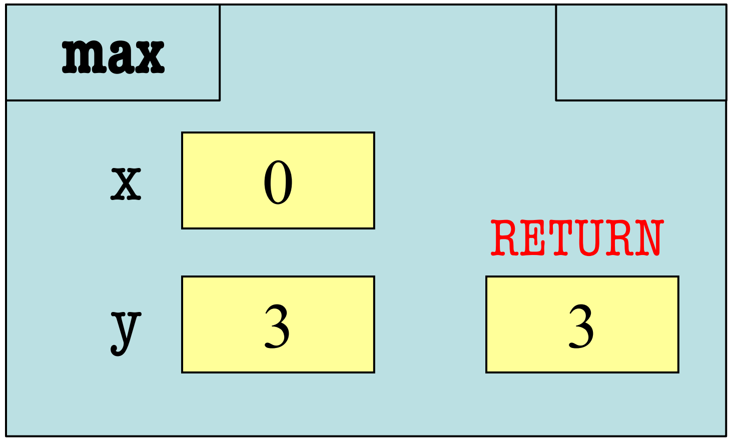
```

max(0,3):



Frame sequence depends on flow

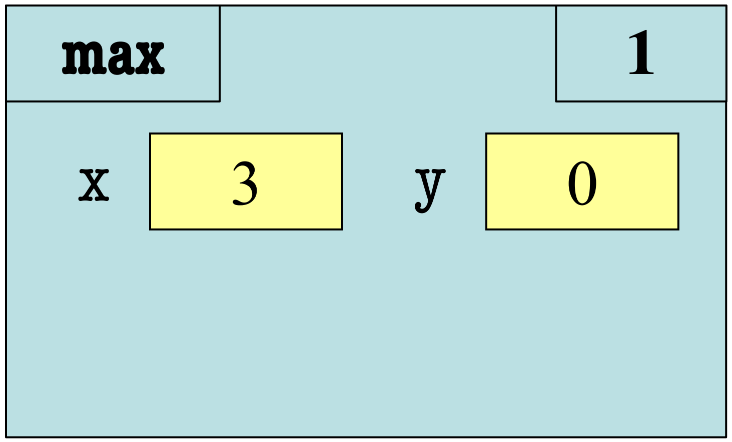
Skips line 2

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
```

- max(3,0):



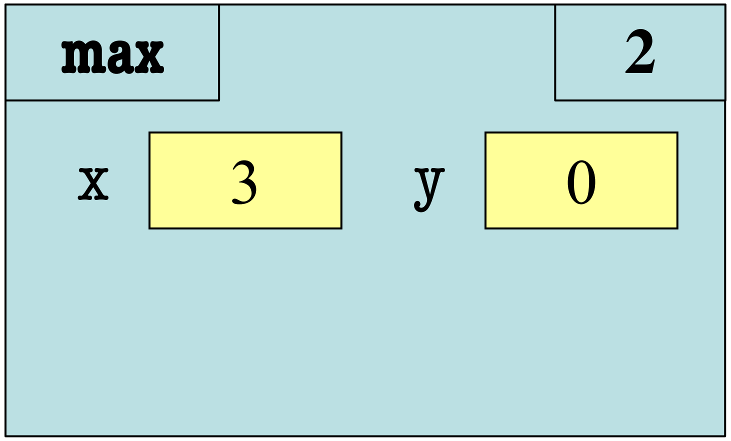
Swaps max into var y

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
```

- max(3,0):



Swaps max into var y

Program Flow vs. Local Variables

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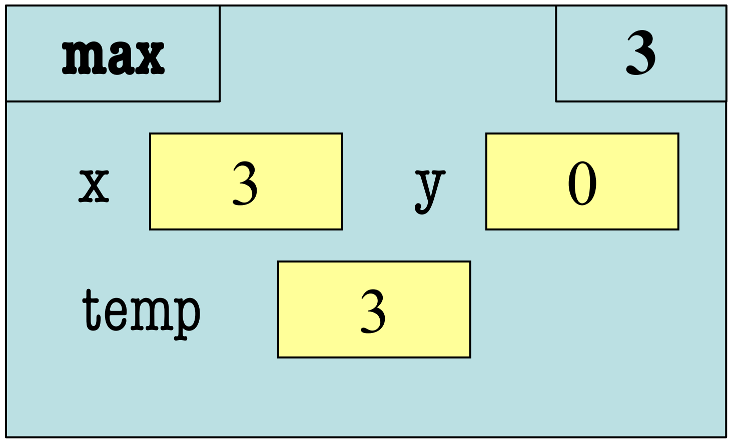
      """Returns: max of x, y"""
      # swap x, y
      # put the larger in y
1     if x > y:
2         temp = x
3         x = y
4         y = temp

5     return y
```

- max(3,0):



Swaps max into var y

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
```

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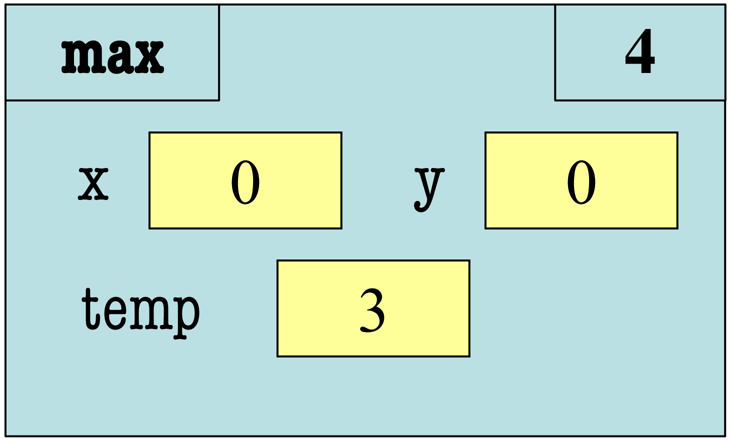

Swaps max into var y

Program Flow vs. Local Variables

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

5     return y
```

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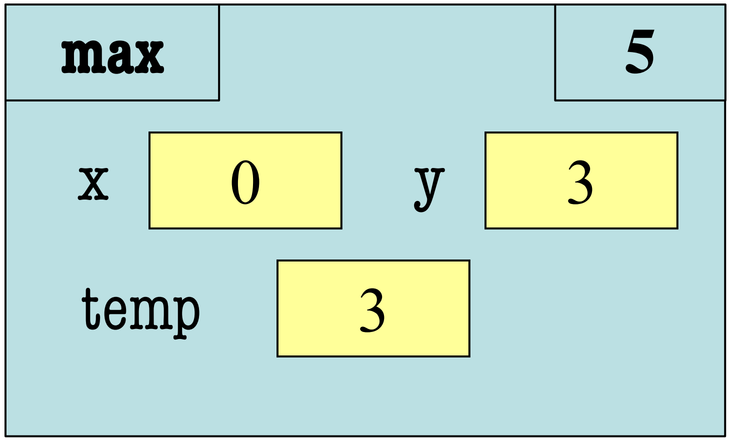


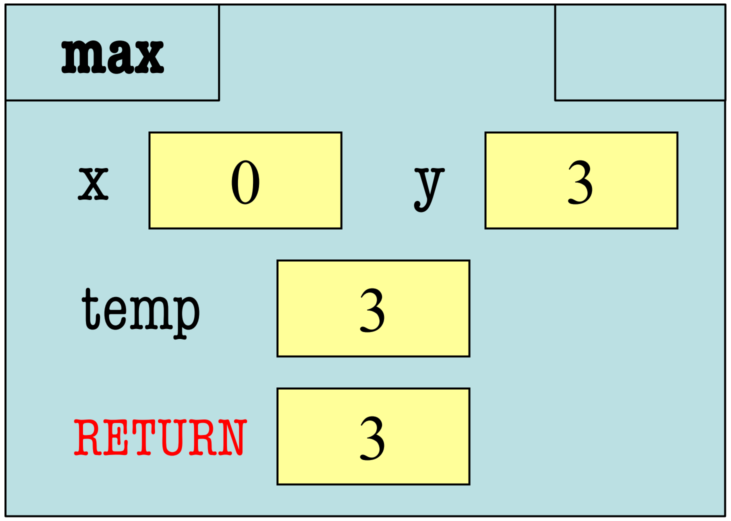
Swaps max into var y

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
```

- max(3,0):



Swaps max into var y

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 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
1     if x > y:
2         temp = x
3         x = y
4         y = temp

5     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
1     if x > y:
2         temp = x
3         x = y
4         y = temp

5     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

Testing and Code Coverage

- Typically, tests are written from **specification**
  - This is because they should be written first
  - You run these tests while you implement
- But sometimes tests leverage code structure
  - You know the control-flow branches
  - You want to make sure each branch is correct
  - So you explicitly have a test for **each branch**
- This is called **code coverage**

Which Way is Correct?

- Code coverage requires knowing code
  - So it must be done after implementation
  - But best practice is to write tests *first*
- Do them **BOTH**
  - Write tests from the specification
  - Implement the function while testing
  - Go back and add tests for full coverage
  - Ideally this does not require adding tests

Recall: Debugging

- 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-name, first-name' """
    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

Called **watches**

Now Have a Different Challege

```
# 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')
```

- What was executed?
  - The if -statement?
  - Or the else-statement?
- More print statements
  - **Trace** program flow
  - Verify flow is correct

Called **traces**

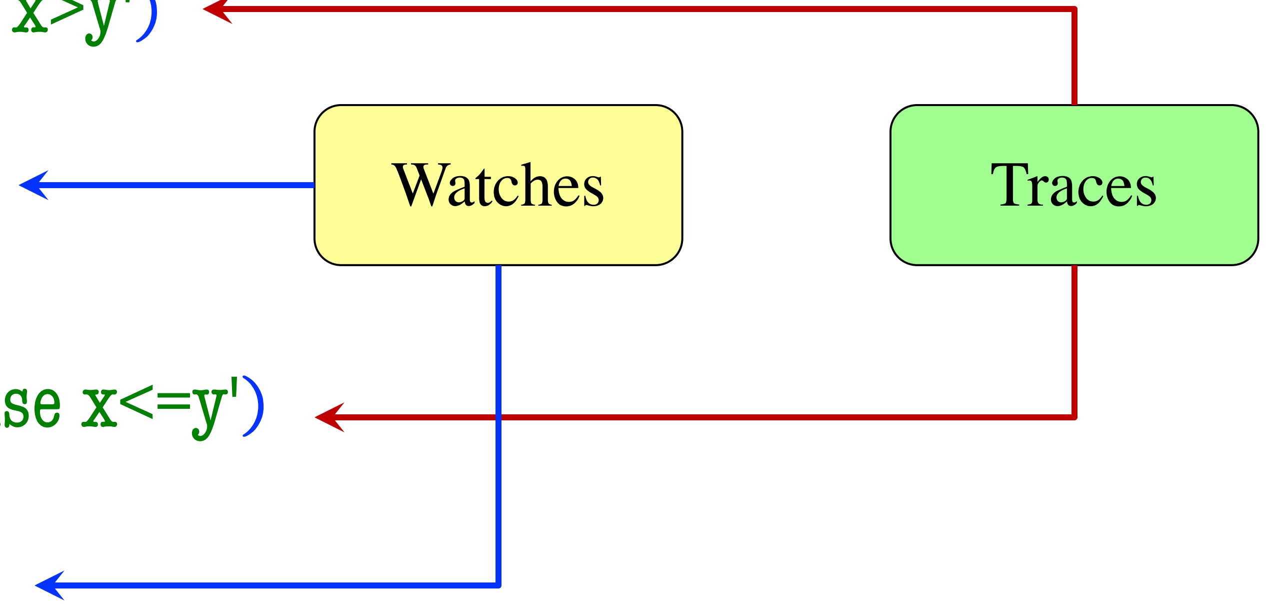
Watches vs. Traces

Watch	Trace
• Visualization tool ▪ Often `print/log` statement ▪ May have IDE support	• Visualization tool ▪ Often `print/log` statement ▪ May have IDE support
• Looks at **variable value** ▪ Anywhere it can change ▪ Often after assignment	• Looks at **program flow** ▪ Anywhere it can change ▪ Before/after control

Traces and Functions

Example: flow.py

```
print('before if')
if x > y:
    print('if x>y')
    z = y
    print(z)
else:
    print('else x<=y')
    z = y
    print(z)
print('after if')
```



Conditionals: If-Elif-Else-Statements

Format

```
if expression :
    statement
    …
elif 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

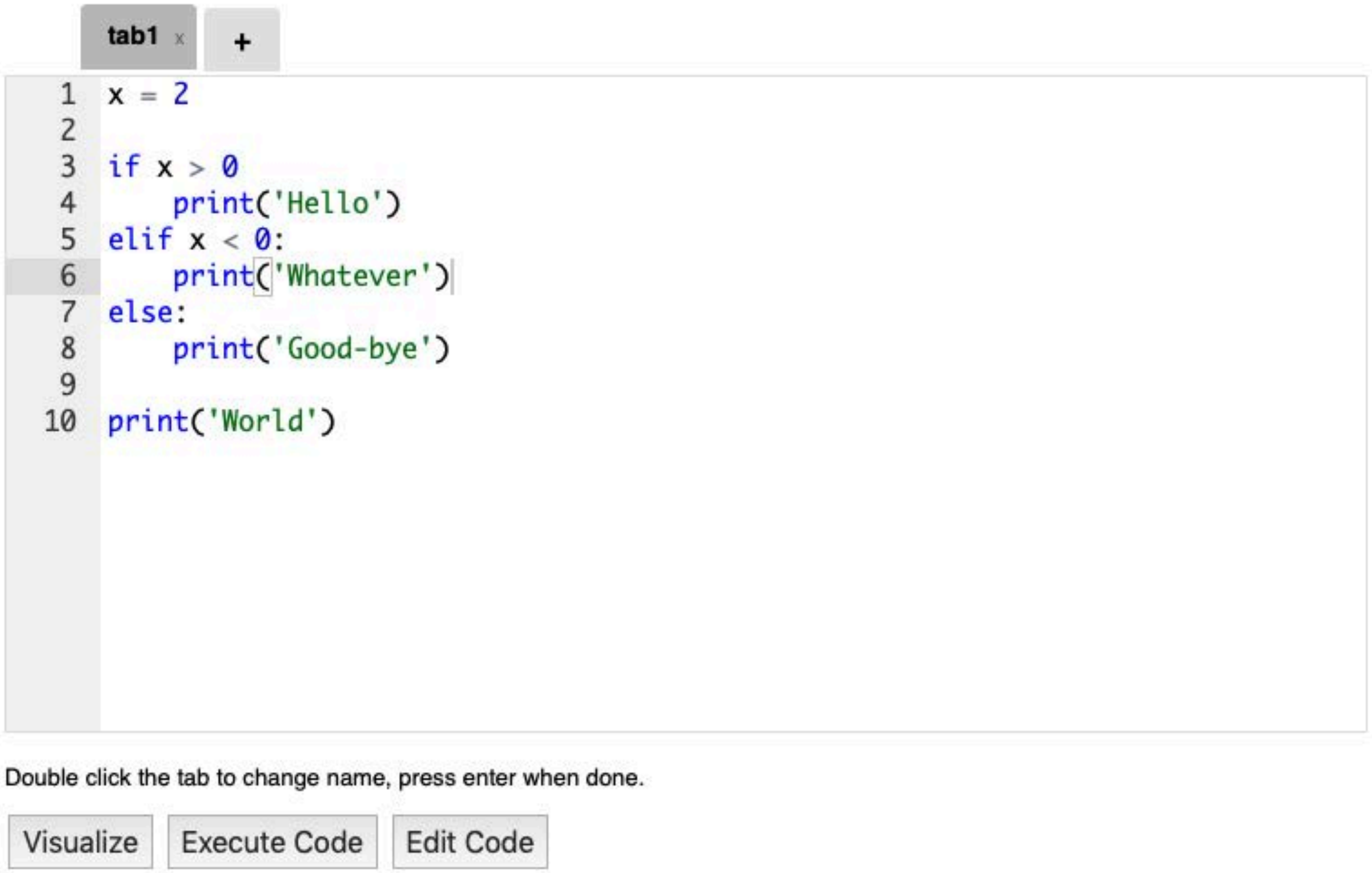
Format

```
if expression :
        statement
        …
elif 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 first True, skips over all others
  - else means **all** are false

Python Tutor Example



```
x = 2

if x > 0
    print('Hello')
elif x < 0:
    print('Whatever')
else:
    print('Good-bye')

print('World')
```

Conditional Expressions

Format

`e1 if bexp else e2`

- `e1` and `e2` are *any* expression
- `bexp` is a boolean expression
- This is an expression!
  - **Evaluates** to `e1` if `bexp` True
  - **Evaluates** to `e2` if `bexp` False

Example

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

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