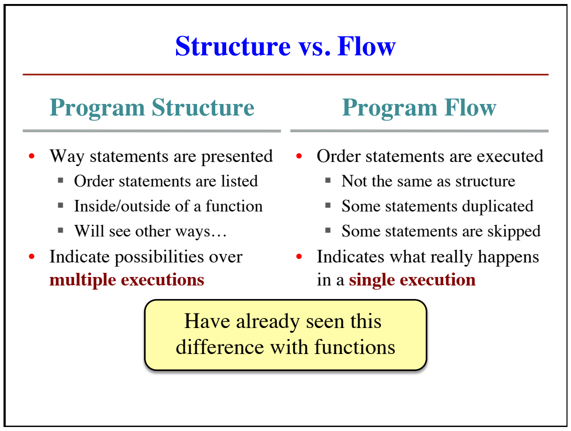


## Structure vs. Flow

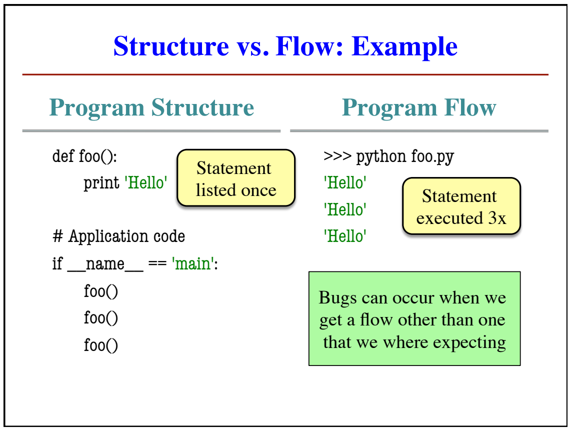
### Program Structure

- 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'

# Application code
if __name__ == 'main':
    foo()
    foo()
    foo()
```

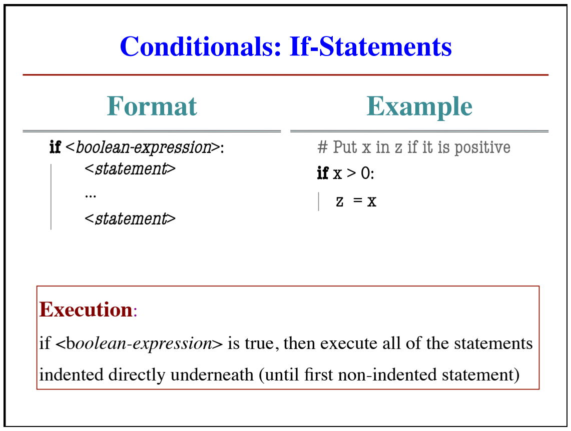
Statement listed once

### 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

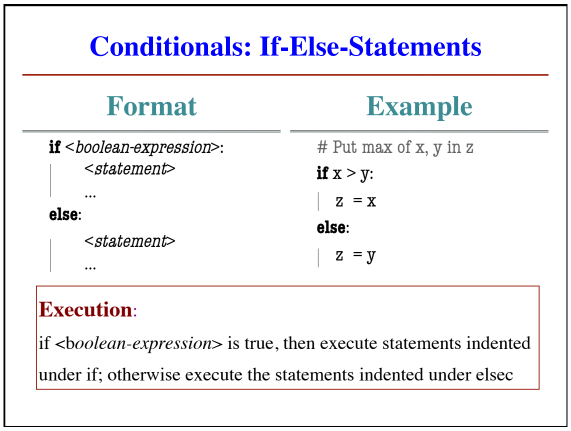
```
if <boolean-expression>:
    <statement>
    …
    <statement>
```

### 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

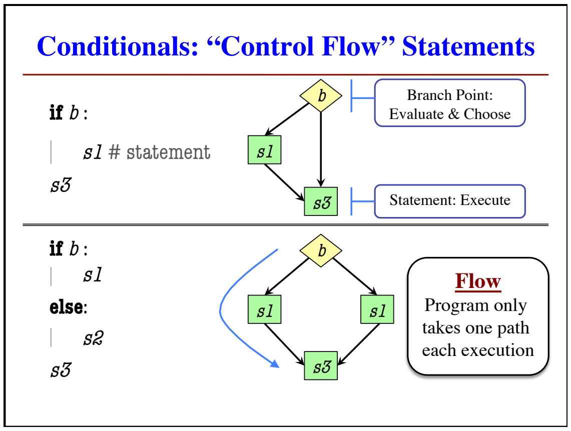
```
if <boolean-expression>:
    <statement>
    …
else:
    <statement>
    …
```

### Example

```
# 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

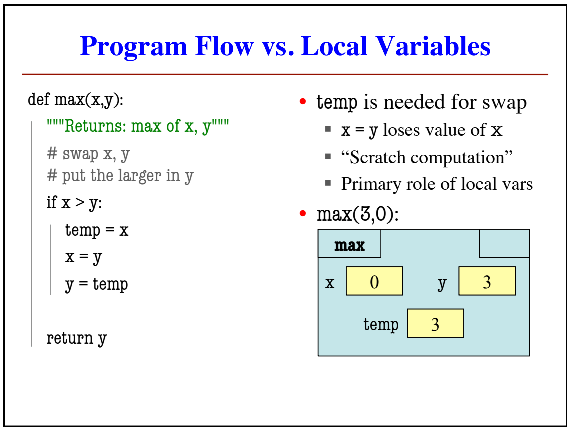
```
if b :
    s1 # statement
s3
```

Branch Point: Evaluate & Choose

Statement: Execute

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

**Flow**
Program only takes one path each execution



## 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
```

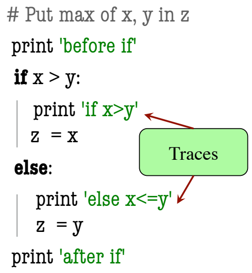
- Value of max(3,0)?

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

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

## 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.)

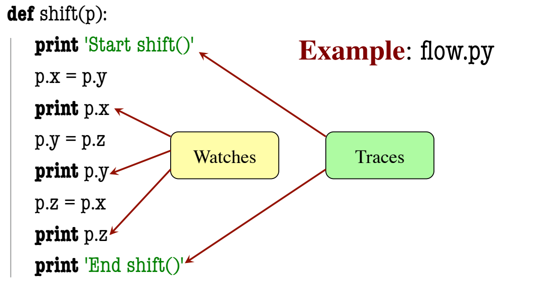


```
# Put max of x, y in z
print 'before if'
if x > y:
    print 'if x>y'
    z = x
else:
    print 'else x<=y'
    z = y
print 'after if'
```

## 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 shift(p):
    print 'Start shift()'
    p.x = p.y
    print p.x
    p.y = p.z
    print p.y
    p.z = p.x
    print p.z
    print 'End shift()'
```

**Example**: flow.py

## 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

## 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
```