

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

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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

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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

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Structure vs. Flow

Program Structure

- Order code is **presented**
 - Order statements are listed
 - Inside/outside of function
 - Will see other ways...

Program Flow

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

Have already seen this difference with functions

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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

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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**.

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Conditionals: "Control Flow" Statements

```

if b:
|  s1 # statement
s3

```

```

if b:
|  s1
else:
|  s2
s3

```

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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

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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**

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Watches vs. Traces

Watch	Trace
<ul style="list-style-type: none"> • Visualization tool <ul style="list-style-type: none"> ▪ Often print/log statement ▪ May have IDE support • Looks at variable value <ul style="list-style-type: none"> ▪ Anywhere it can change ▪ Often after assignment 	<ul style="list-style-type: none"> • Visualization tool <ul style="list-style-type: none"> ▪ Often print/log statement ▪ May have IDE support • Looks at program flow <ul style="list-style-type: none"> ▪ Anywhere it can change ▪ Before/after control

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Traces and Functions

```

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')

```

Example: flow.py

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Conditionals: If-Elif-Else-Statements

Format	Notes on Use
<pre> if expression: statement ... elif expression: statement ... else: statement ... </pre>	<ul style="list-style-type: none"> • No limit on number of elif <ul style="list-style-type: none"> ▪ Can have as many as want ▪ Must be between if, else • The else is always optional <ul style="list-style-type: none"> ▪ if-elif by itself is fine • Booleans checked in order <ul style="list-style-type: none"> ▪ Once it finds first True, skips over all others ▪ else means all are false

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