Print and None

(Demo)
None Indicates that Nothing is Returned

The special value `None` represents nothing in Python.

A function that does not explicitly return a value will return `None`.

**Careful:** `None` is *not displayed* by the interpreter as the value of an expression.

```
>>> def does_not_return_square(x):
...    x * x
...    
...

>>> does_not_return_square(4)

>>> sixteen = does_not_return_square(4)

>>> sixteen + 4

Traceback (most recent call last):
  File "<stdin>", line 1, in <module>
TypeError: unsupported operand type(s) for +: 'NoneType' and 'int'
```
Pure Functions & Non-Pure Functions

### Pure Functions
*just return values*

- `-2` > **abs** > 2
- `2, 100` > **pow** > `1267650600228229401496703205376`

### Non-Pure Functions
*have side effects*

- `-2` > **print** > None

**Python displays the output “-2”**

(Demo)

A side effect isn't a value; it's anything that happens as a consequence of calling a function.
Nested Expressions with Print

None, None ➔

\[
\text{print(...):} \quad \text{None} \quad \text{Does not get displayed}
\]

display “None None”

\[
>>> \text{print(print(1), print(2))}
1
2
None None
\]

\[
\text{func print(...)}
\]

\[
\text{print(print(1), print(2))}
\]

\[
\text{None}
\]

\[
\text{func print(...)}
\]

\[
\text{None}
\]

\[
\text{print(1)}
\]

\[
\text{1}
\]

\[
\text{func print(...)}
\]

\[
\text{None}
\]

\[
\text{print(2)}
\]

\[
\text{2}
\]

\[
\text{1} \text{ ➔}
\]

\[
\text{print(...):} \quad \text{None}
\]

display “1”

\[
\text{2} \text{ ➔}
\]

\[
\text{print(...):} \quad \text{None}
\]

display “2”
Life Cycle of a User-Defined Function

Def statement:

- Name: `square(x)`
- Formal parameter: `x`
- Body (return expression):
  - `return mul(x, x)`

What happens?

A new function is created!

Name bound to that function in the current frame.

Call expression:

- `square(2+2)`
- Operand: `2+2`
  - Argument: `4`
- Operator: `square`
  - Function: `func square(x)`

What happens?

Operator & operands evaluated.

Function (value of operator) called on arguments (values of operands).

Calling/Applying:

- Argument: `4`
  - Signature: `square(x)`
  - Return value: `16`

What happens?

A new frame is created!

Parameters bound to arguments.

Body is executed in that new environment.
Miscellaneous Python Features

Division
Multiple Return Values
Source Files
Doctests
Default Arguments

(Demo)
Conditional Statements
A *statement* is executed by the interpreter to perform an action

**Compound statements:**

The first header determines a statement’s type

The header of a clause “controls” the suite that follows

`def` statements are compound statements
Compound Statements

**Compound statements:**

- `<header>`:
  - `<statement>`
  - `<statement>`
  - ...

- `<separating header>`:
  - `<statement>`
  - `<statement>`
  - ...

A suite is a sequence of statements

To “execute” a suite means to execute its sequence of statements, in order

**Execution Rule for a sequence of statements:**

- Execute the first statement
- Unless directed otherwise, execute the rest
Conditional Statements

(Demo)

```python
def absolute_value(x):
    """Return the absolute value of x."""
    if x < 0:
        return -x
    elif x == 0:
        return 0
    else:
        return x
```

Execution Rule for Conditional Statements:

1. Evaluate the header's expression.
2. If it is a true value, execute the suite & skip the remaining clauses.

Syntax Tips:

1. Always starts with "if" clause.
2. Zero or more "elif" clauses.
3. Zero or one "else" clause, always at the end.
def absolute_value(x):
    """Return the absolute value of x."""
    if x < 0:
        return -x
    elif x == 0:
        return 0
    else:
        return x
def absolute_value(x):
    """Return the absolute value of x."""
    if x < 0:
        return -x
    elif x == 0:
        return 0
    else:
        return x

Boolean Contexts

False values in Python:  False, 0, '', None  (more to come)

True values in Python:  Anything else (True)

George Boole

Read Section 1.5.4!

Reading:  http://composingprograms.com/pages/15-control.html#conditional-statements
While Statements

(Demo)

1  i, total = 0, 0
2  while i < 3:
3     i = i + 1
4     total = total + i

Global frame

<table>
<thead>
<tr>
<th>i</th>
<th>3</th>
</tr>
</thead>
<tbody>
<tr>
<td>total</td>
<td>6</td>
</tr>
</tbody>
</table>

Execution Rule for While Statements:

1. Evaluate the header’s expression.

2. If it is a true value, execute the (whole) suite, then return to step 1.
Iteration Example
def fib(n):
    """Compute the nth Fibonacci number, for N >= 1."""
    pred, curr = 0, 1  # 0th and 1st Fibonacci numbers
    k = 1              # curr is the kth Fibonacci number
    while k < n:
        pred, curr = curr, pred + curr
        k = k + 1
    return curr

The next Fibonacci number is the sum of the current one and its predecessor.

The Fibonacci Sequence

0, 1, 1, 2, 3, 5, 8, 13, 21, 34, 55, 89, 144, 233, 377, 610, 987
Go Bears!
Return Statements

A return statement completes the evaluation of a call expression and provides its value:

f(x) for user-defined function f: switch to a new environment; execute f's body

return statement within f: switch back to the previous environment; f(x) now has a value

Only one return statement is ever executed while executing the body of a function

def end(n, d):
    """Print the final digits of N in reverse order until D is found."

    >>> end(34567, 5)
    7
    6
    5
    """
    while n > 0:
        last, n = n % 10, n // 10
        print(last)
        if d == last:
            return None          (Demo)
Designing Functions
Describing Functions

A function's *domain* is the set of all inputs it might possibly take as arguments.

A function's *range* is the set of output values it might possibly return.

A pure function's *behavior* is the relationship it creates between input and output.

```python
def square(x):
    """Return X * X."""

    x is a number

    square returns a non-negative real number

    square returns the square of x
```
A Guide to Designing Function

Give each function exactly one job, but make it apply to many related situations

```python
>>> round(1.23)
1
>>> round(1.23, 1)
1.2
>>> round(1.23, 0)
1
>>> round(1.23, 5)
1.23
```

Don’t repeat yourself (DRY): Implement a process just once, but execute it many times

(Demo)
Generalization
Generalizing Patterns with Arguments

Regular geometric shapes relate length and area.

Shape:

Area:

Finding common structure allows for shared implementation

(Demo)
Control
If Statements and Call Expressions

Let's try to write a function that does the same thing as an if statement.

```
def if_(c, t, f):
    if c:
        t
    else:
        f
```

**Execution Rule for Conditional Statements:**

- Each clause is considered in order.
- 1. Evaluate the header's expression (if present).
- 2. If it is a true value (or an else header), execute the suite & skip the remaining clauses.

**Evaluation Rule for Call Expressions:**

1. Evaluate the operator and then the operand subexpressions
2. Apply the function that is the value of the operator to the arguments that are the values of the operands
Control Expressions
Logical Operators

To evaluate the expression $\langle \text{left} \rangle \text{ and } \langle \text{right} \rangle$:

1. Evaluate the subexpression $\langle \text{left} \rangle$.
2. If the result is a false value $v$, then the expression evaluates to $v$.
3. Otherwise, the expression evaluates to the value of the subexpression $\langle \text{right} \rangle$.

To evaluate the expression $\langle \text{left} \rangle \text{ or } \langle \text{right} \rangle$:

1. Evaluate the subexpression $\langle \text{left} \rangle$.
2. If the result is a true value $v$, then the expression evaluates to $v$.
3. Otherwise, the expression evaluates to the value of the subexpression $\langle \text{right} \rangle$.
Conditional Expressions

A conditional expression has the form

\[ \text{<consequent>} \ \text{if} \ \text{<predicate>} \ \text{else} \ \text{<alternative>} \]

**Evaluation rule:**

1. Evaluate the `<predicate>` expression.

2. If it's a true value, the value of the whole expression is the value of the `<consequent>`.

3. Otherwise, the value of the whole expression is the value of the `<alternative>`.

```python
>>> x = 0
>>> abs(1/x if x != 0 else 0)
0
```