Control

Class outline:

- Side effects
- More function features
- Conditionals
- Booleans
- Iteration

Side effects

The None value

The special value `None` represents nothingness in Python.

Any function that doesn't explicitly return a value will return `None`:

```
def square_it(x):
  x * x
```

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When a function returns `None`, the console shows no output at all:

```
square_it(4)
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def square_it(x):
  x * x
```

When a function returns `None`, the console shows no output at all:

```
square_it(4)
```

Attempting to treat the `None` like a number will result in an error:

```
sixteen = square_it(4)
sum = sixteen + 4     #  TypeError!
```

Side effects

A **side effect** is when something happens as a result of calling a function besides just returning a value.

The most common side effect is logging to the console, via the built-in `print()` function.

```
print(-2)
```

Other common side effects: writing to files, drawing graphics on the screen.

Side effects vs. Return values

```
def square_num1(number):
    return pow(number, 2)
```

```
def square_num2(number):
    print(number ** 2)
```

- Which one has a side effect?

- What data type do they each return?

Side effects vs. Return values

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  The second function has a side effect, because it prints to the console.

- What data type do they each return?

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- Which one has a side effect?
  The second function has a side effect, because it prints to the console.

- What data type do they each return?
  The first function returns a number, the second one returns `None`.

Pure vs. non-pure functions

	Arguments		Return value
Pure functions just return values.	-2		2
	2, 10		1024

Pure vs. non-pure functions

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Pure functions just return values.	-2		2
	2, 10		1024
Non-pure functions have side effects.	-2	 Python displays output "-2"	None

Nested print statements

What will this display?

```
print(print(1), print(2))
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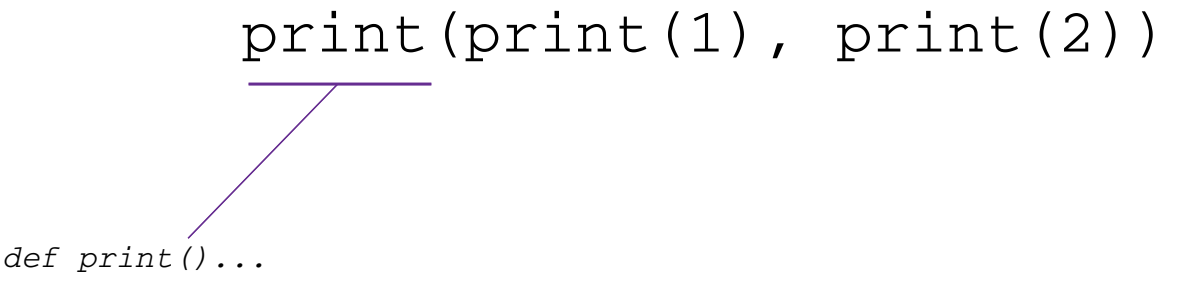

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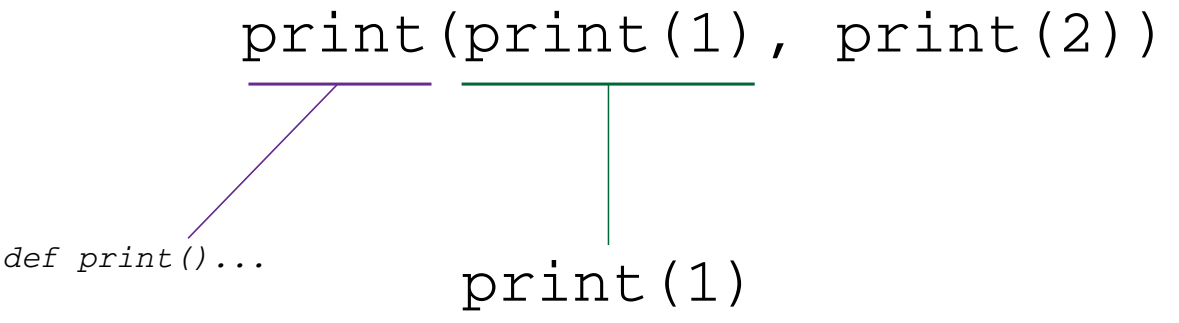

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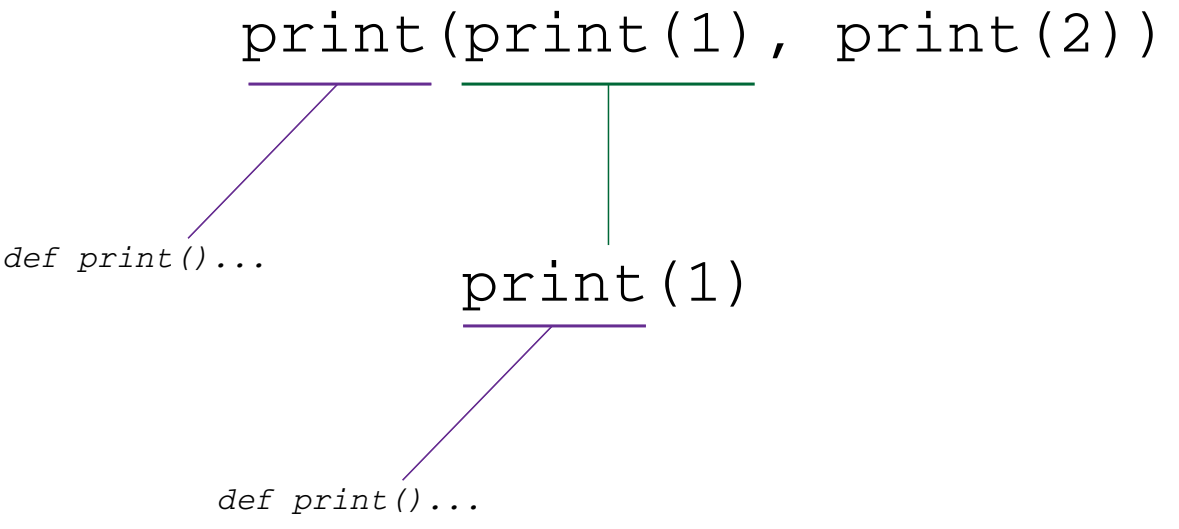

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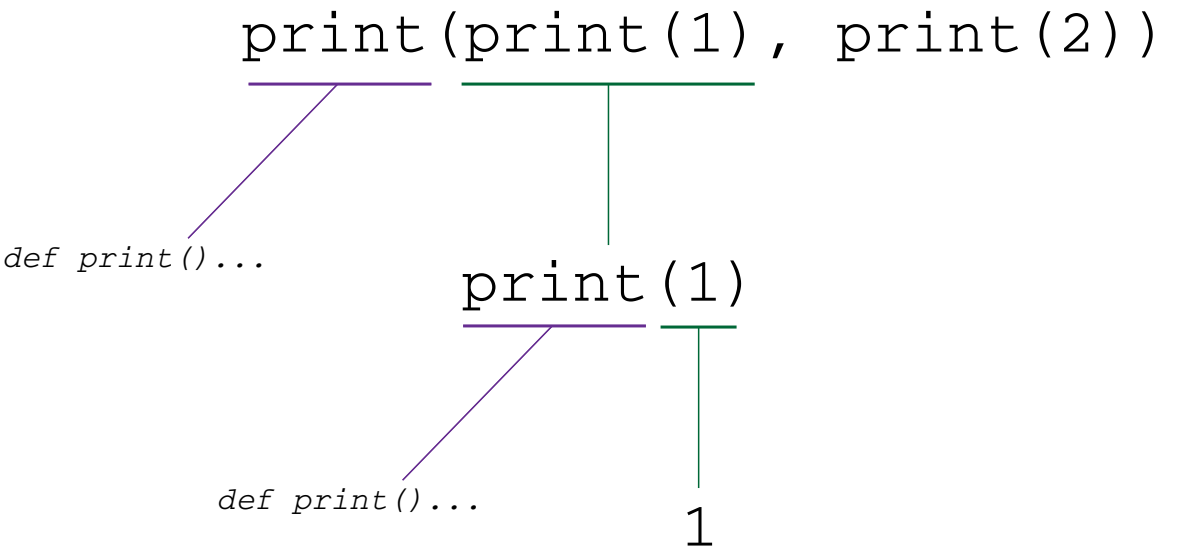

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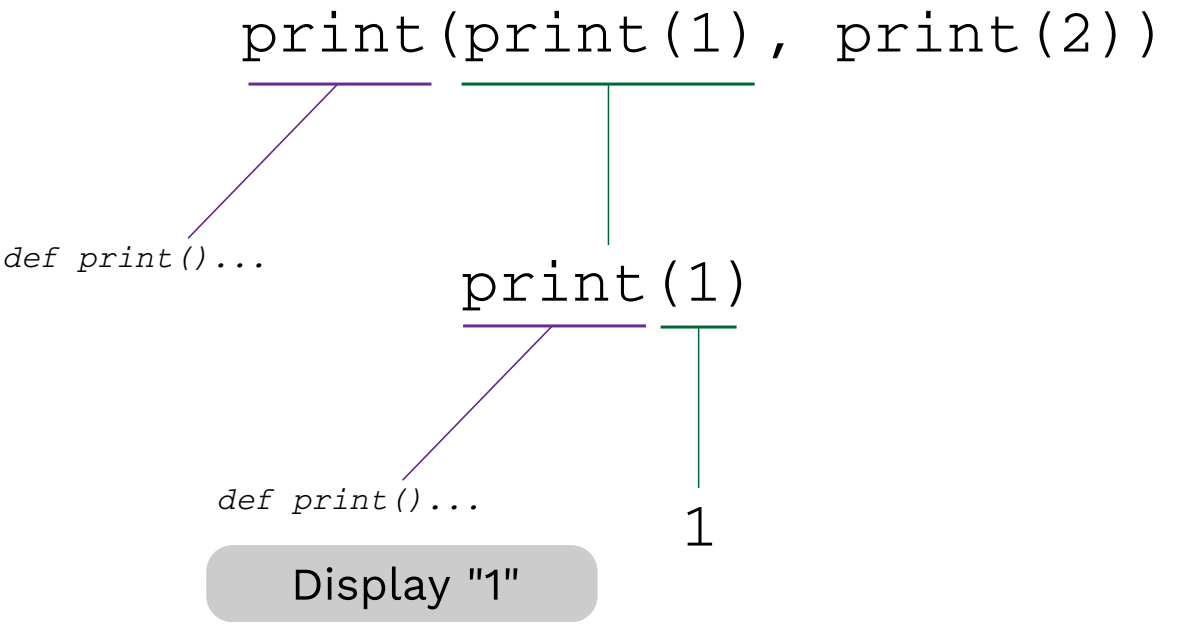

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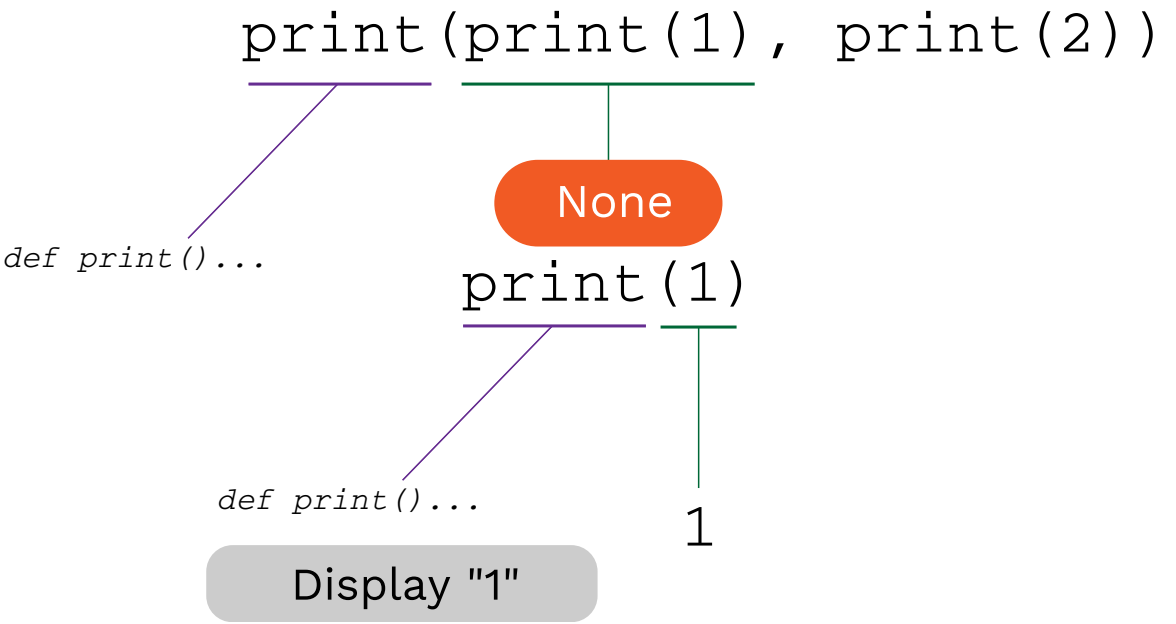

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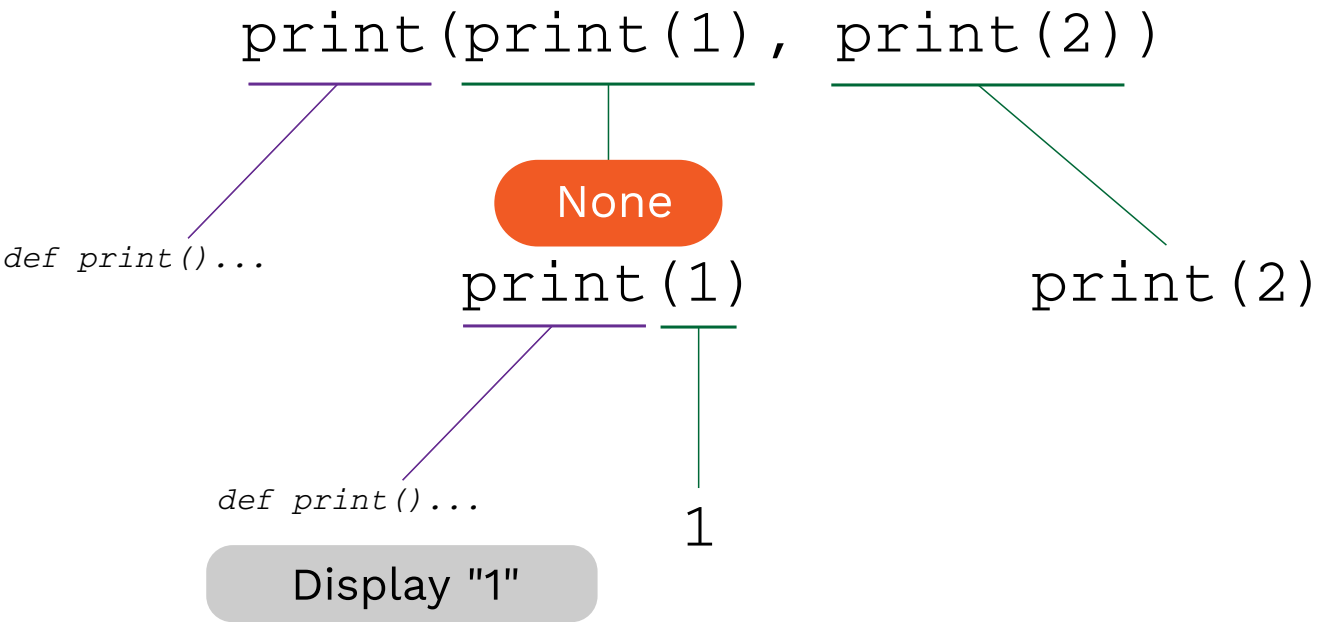

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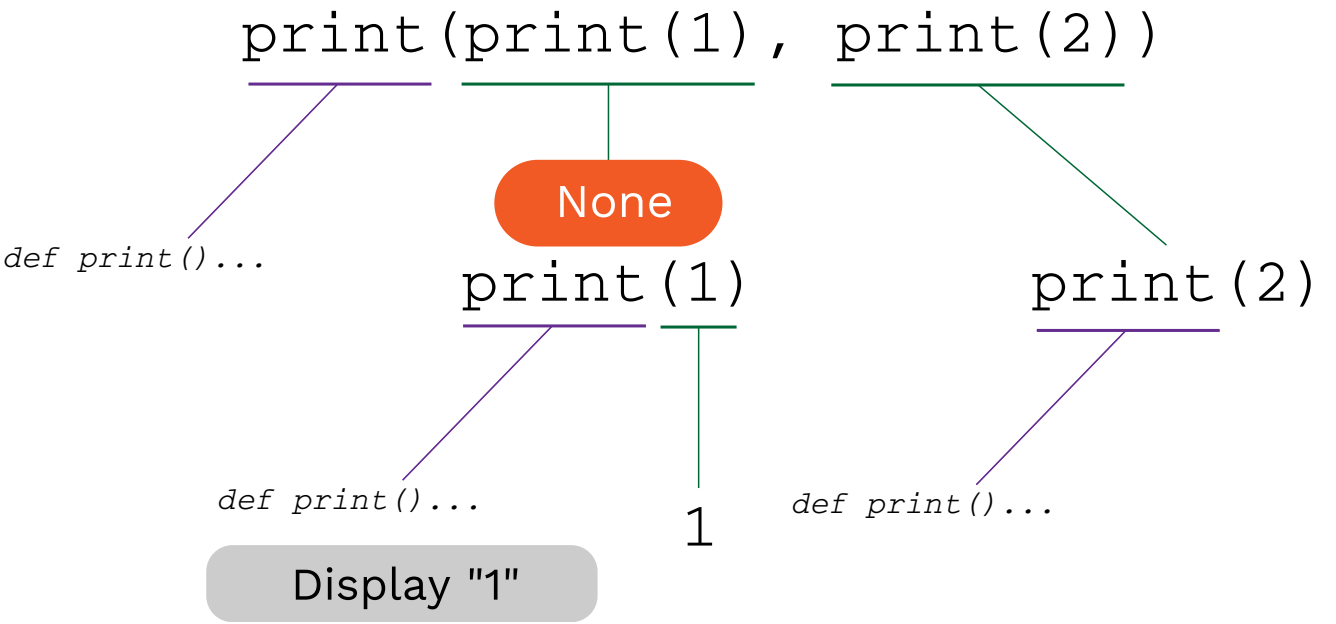

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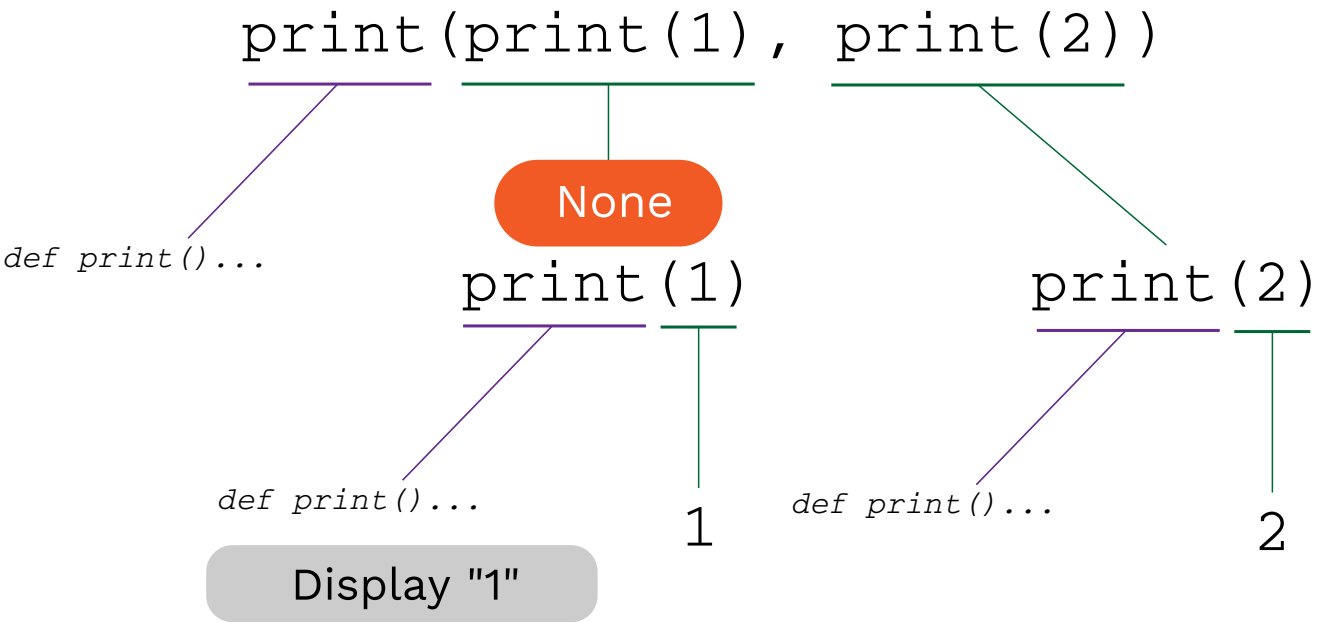

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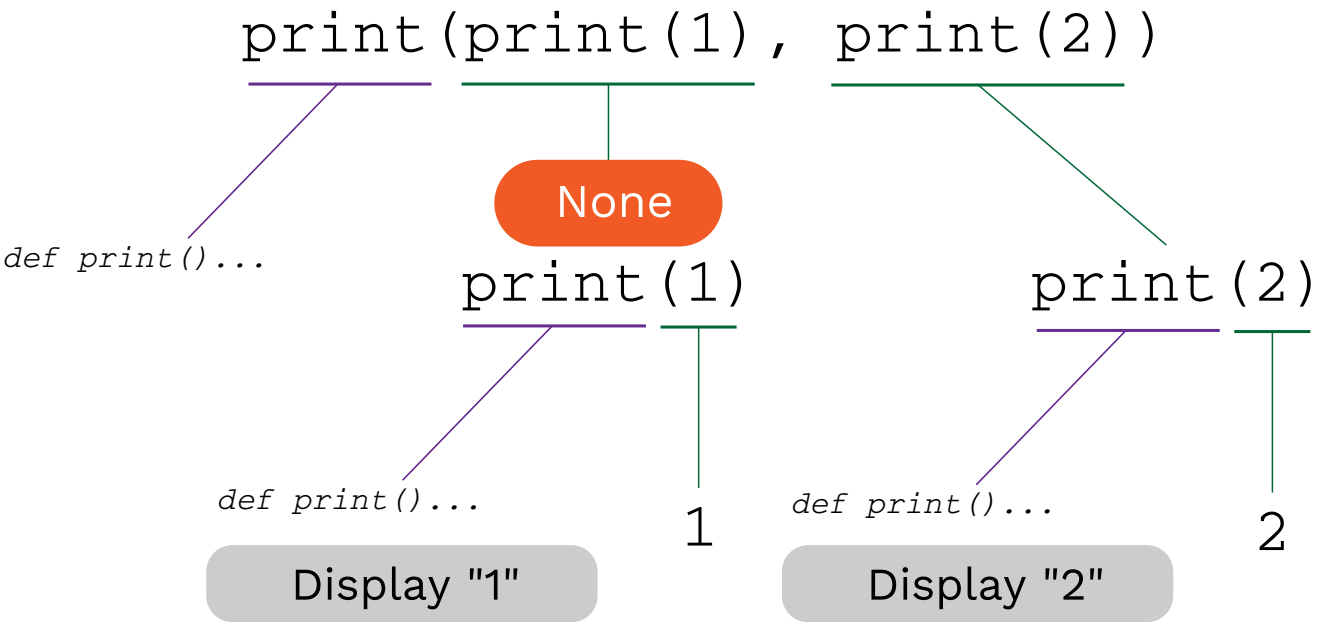

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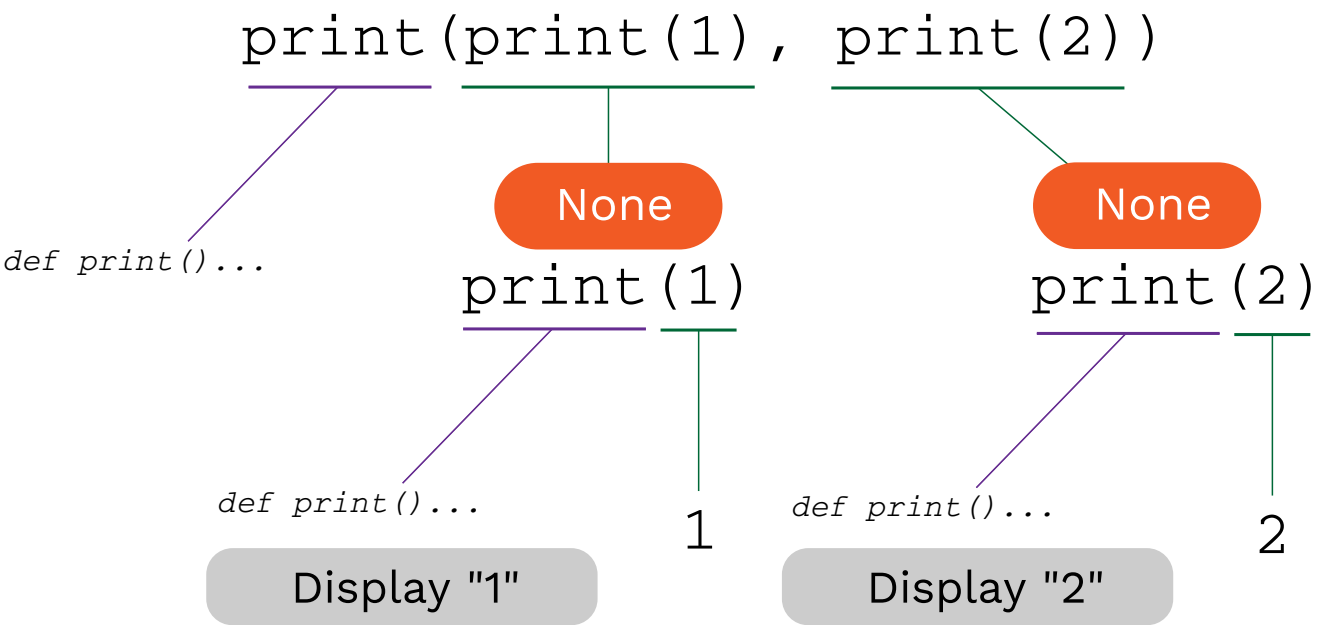

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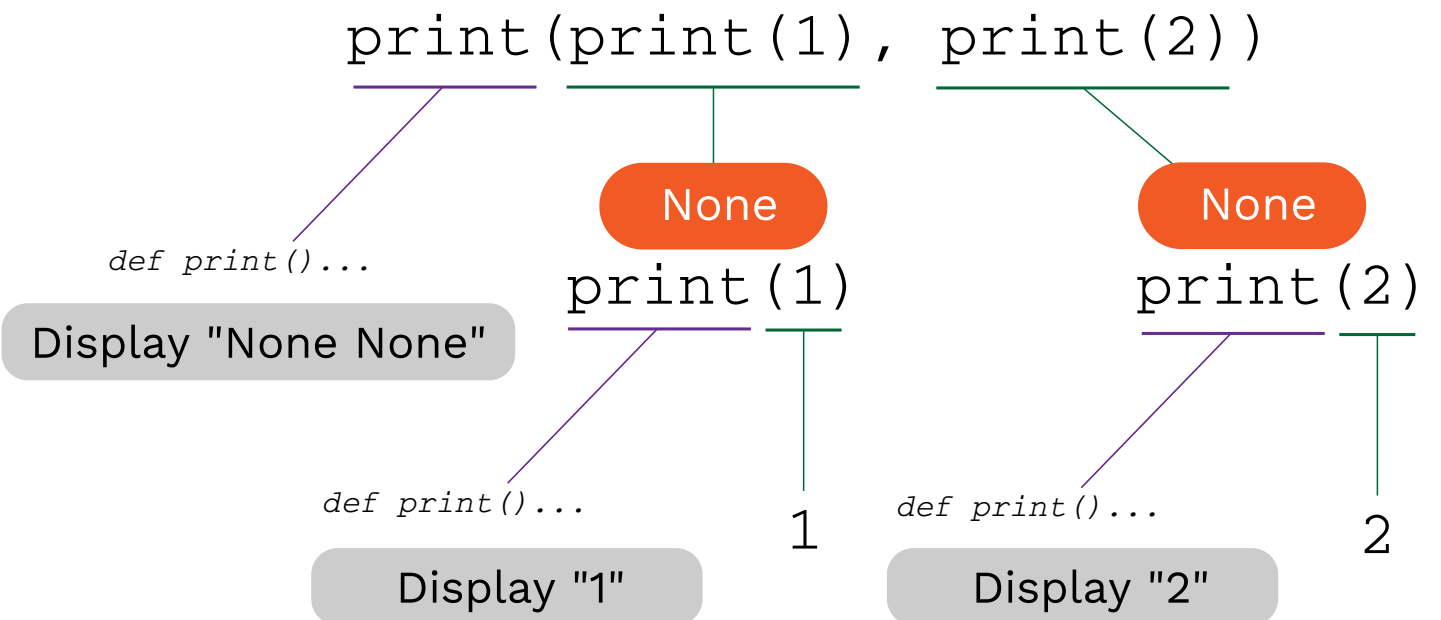

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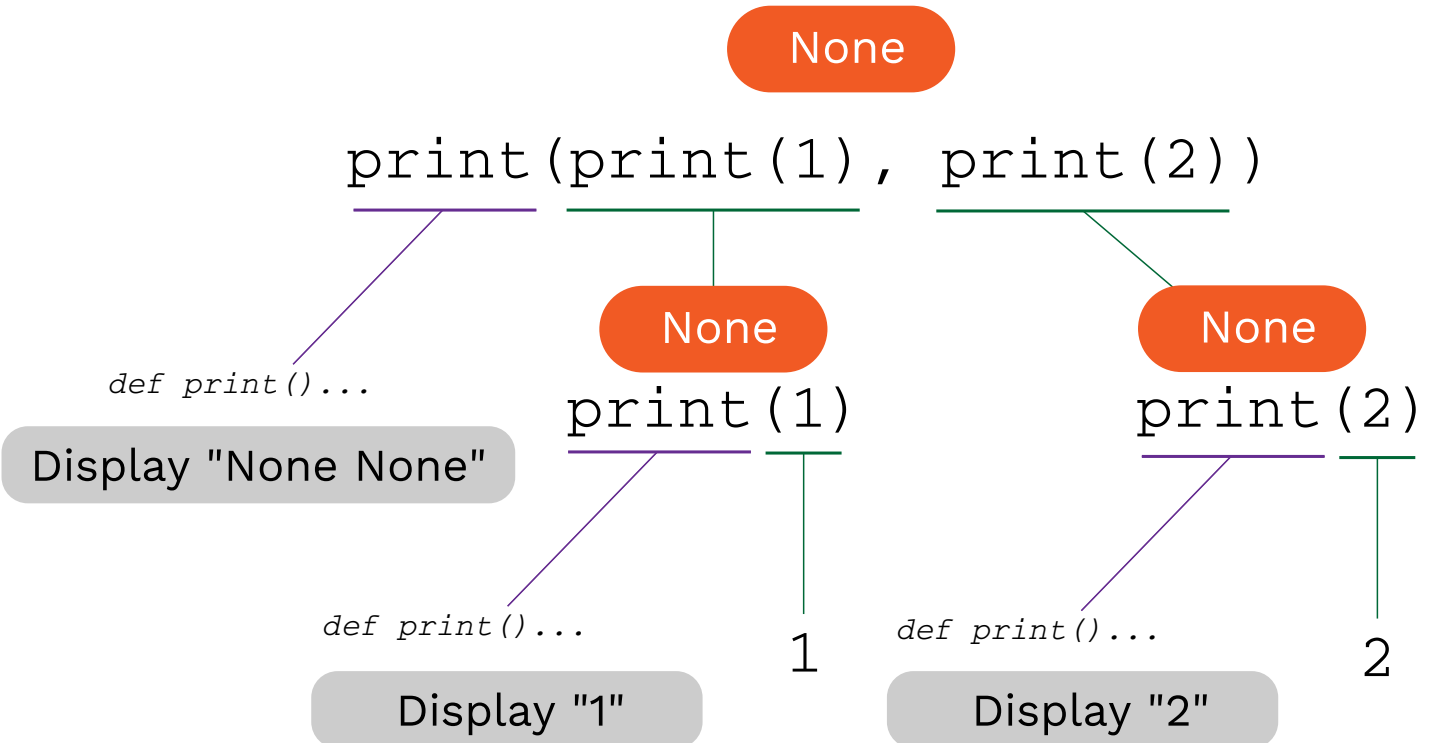

More function features

Default arguments

In the function signature, a parameter can specify a **default value**. If that argument isn't passed in, the default value is used instead.

```
def calculate_dog_age(human_years, multiplier = 7):
    return human_years * multiplier
```

These two lines of code have the same result:

```
calculate_dog_age(3)
calculate_dog_age(3, 7)
```

Default arguments can be overriden two ways:

```
calculate_dog_age(3, 6)
calculate_dog_age(3, multiplier=6)
```

Multiple return values

A function can specify multiple return values, separated by commas.

```
def divide_exact(n, d):
    quotient = n // d
    remainder = n % d
    return quotient, remainder
```

Any code that calls that function must also "unpack it" using commas:

```
q, r = divide_exact(618, 10)
```

Doctests

Doctests check the input/output of functions.

```
def divide_exact(n, d):
    """
    >>> q, r = divide_exact(2021, 10)
    >>> q
    202
    >>> r
    1
    """
    quotient = n // d
    remainder = n % d
    return quotient, remainder
```

See more in Python doctests documentation.

Boolean expressions

Booleans

A **Boolean value** is either `True` or `False` and is used frequently in computer programs.

Google Maps uses a boolean to decide whether to avoid highways in driving directions:

```
avoid_highways = True
```

Twitter uses a boolean to remember where the user allows personalized ads:

```
personalized_ads = False
```

Boolean expressions

An expression can evaluate to a Boolean. Most Boolean expressions use either comparison or logical operators.

An expression with a comparison operator:

```
passed_class = grade > 65
```

An expression with a logical operator:

```
wear_jacket = is_raining or is_windy
```

Comparison operators

Operator	Meaning	True expressions
==	Equality	`32 == 32`, `'a' == 'a'`
!=	Inequality	`30 != 32`, `'a' != 'b'`
>	Greater than	`60 > 32`
>=	Greater than or equal	`60 >= 32` , `32 >= 32`
<	Less than	`20 < 32`
<=	Less than or equal	`20 <= 32`, `32 <= 32`

⚠ Common mistake: Do not confuse `=` (the assignment operator) with `==` (the equality operator).

Logical operators

Operator	True expressions	Meaning
`and`	`4 > 0 and -2 < 0`	Evaluates to `True` if both conditions are true. If one is `False` evaluates to `False`.
`or`	`4 > 0 or -2 > 0`	Evaluates to `True` if either condition is true. Evaluates to `False` only if both are false.
`not`	`not (5 == 0)`	Evaluates to `True` if condition is false; evaluates to `False` if condition is true.

Compound booleans

When combining multiple operators in a single expression, use parentheses to group:

```
may_have_mobility_issues = (age >= 0 and age < 2)  or age > 90
```

Boolean expressions in functions

A function can use a Boolean expression to return a result based on the values of the parameters.

```
def passed_class(grade):
    return grade > 65
```

```
def should_wear_jacket(is_rainy, is_windy):
    return is_rainy or is_windy
```

Exercise

These are un-graded exercises you can do after the lecture to make sure you grok the basics:

- has_curly_hair()
- can_be_president()
- is_safe_to_eat()
- harvest_time()

Statements

Statements

A **statement** is executed by the interpreter to perform an action.

So far we've seen a few...

Statement type	Example
Assignment statement	`name = 'sosuke'` `greeting = 'ahoy, ' + name`
Def statement	`def greet(name):` `    return 'ahoy, ' + name`
Return statement	`return 'ahoy, ' + name`

Compound statements

A **compound statement** contains groups of other statements.

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

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

Compound statements

A **compound statement** contains groups of other statements.

```
<header>:                              # CLAUSE
       <statement>
       <statement>
       ...
<separating header>:                   # CLAUSE
      <statement>
      <statement>
      ...
```

Compound statements

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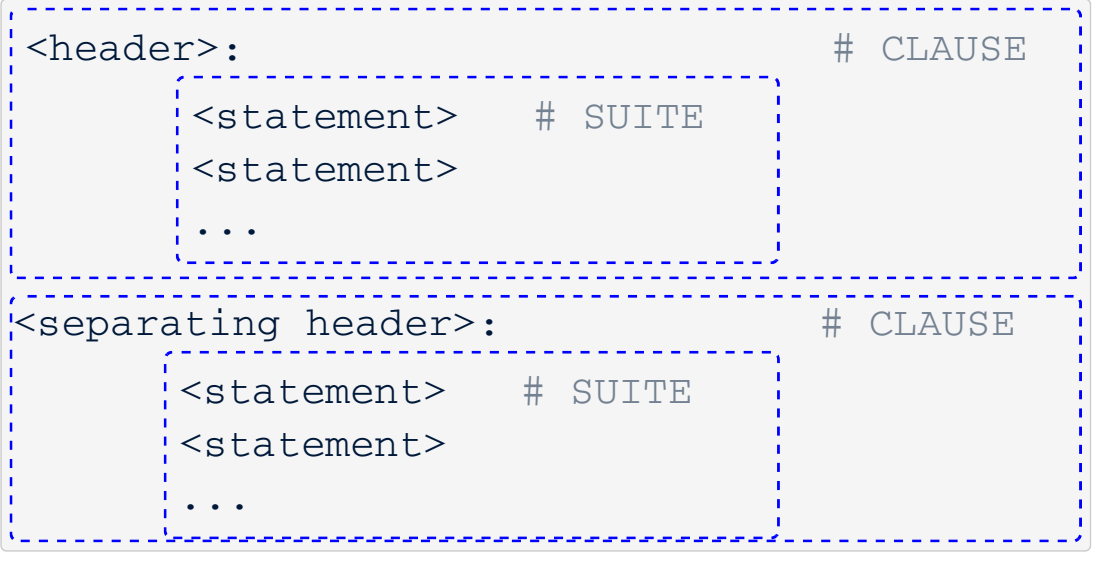


Compound statements

A **compound statement** contains groups of other statements.

```
<header>:                          # CLAUSE
    <statement>    # SUITE
    <statement>
    ...
<separating header>:               # CLAUSE
    <statement>    # SUITE
    <statement>
    ...
```

The first header determines a statement's type, and the header of each clause controls the suite that follows.

Execution of suites

A **suite** is a sequence of statements.

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

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

Execution rule for a sequence of statements:

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

Execution of suites

A **suite** is a sequence of statements.

```
<header>:
        <statement>    # SUITE
        <statement>
        ...

<separating header>:
        <statement>    # SUITE
        <statement>
        ...
```

Execution rule for a sequence of statements:

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

Conditional statements

Conditional statements

A **conditional statement** gives your code a way to execute a different suite of code statements based on whether certain conditions are true or false.

```
if <condition>:
    <statement>
    <statement>
    ...
```

A simple conditional:

```
clothing = "shirt"

if temperature < 32:
    clothing = "jacket"
```

Compound conditionals

A conditional can include any number of `elif` statements to check other conditions.

```
if <condition>:
    <statement>
    ...
elif <condition>:
    <statement>
    ...
elif <condition>:
    <statement>
    ...
```

```
clothing = "shirt"

if temperature < 0:
    clothing = "snowsuit"
elif temperature < 32:
    clothing = "jacket"
```

The else statement

A conditional can include an `else` to specify code to execute if no previous conditions are true.

```
if <condition>:
    <statement>
    ...
elif <condition>:
    <statement>
    ...
else <condition>:
    <statement>
    ...
```

```
if temperature < 0:
    clothing = "snowsuit"
elif temperature < 32:
    clothing = "jacket"
else:
    clothing = "shirt"
```

Conditional statements summary

```
if num < 0:
    sign = "negative"
elif num > 0:
    sign = "positive"
else:
    sign = "neutral"
```

Syntax tips:

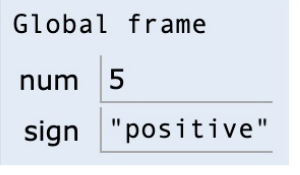
- Always start with `if` clause.
- Zero or more `elif` clauses.
- Zero or one `else` clause, always at the end.

Execution of conditional statements

Each clause is considered in order.

- Evaluate the header's expression.
- If it's true, execute the suite of statements underneath and skip the remaining clauses.
- Otherwise, continue to the next clause.

```
1  num = 5
2
3  if num < 0:
4      sign = "negative"
5  elif num > 0:
6      sign = "positive"
7  else:
8      sign = "neutral"
```

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Conditionals in functions

It's common for a conditional to be based on the value of the parameters to a function.

```
def get_number_sign(num):
    if num < 0:
        sign = "negative"
    elif num > 0:
        sign = "positive"
    else:
        sign = "neutral"
    return sign
```

```
get_number_sign(50)   # "positive"
get_number_sign(-1)   # "negative"
get_number_sign(0)    # "neutral"
```

Returns inside conditionals

A branch of a conditional can end in a return, which exits the function entirely.

```
def get_number_sign(num):
    if num < 0:
        return "negative"
    elif num > 0:
        return "positive"
    else:
        return "neutral"
```

```
get_number_sign(50)   # "positive"
get_number_sign(-1)   # "negative"
get_number_sign(0)    # "neutral"
```

Exercise

These are un-graded exercises you can do after the lecture to make sure you grok the basics:

- greater_num
- hello_world
- assign_grade

While loops

While loops

The while loop syntax:

```
while <condition>:
    <statement>
    <statement>
```

As long as the condition is true, the statements below it are executed.

```
multiplier = 1
while multiplier <= 5:
    print(9 * multiplier)
    multiplier += 1
```

The code is significantly shorter, and it can easily be extended to loop for more or less iterations.

Using a counter variable

It's common to use a **counter variable** whose job is keeping track of the number of iterations.

```
total = 0
counter = 0
while counter < 5:
  total += pow(2, 1)
  counter += 1
```

The counter variable may also be involved in the loop computation:

```
total = 0
counter = 0
while counter < 5:
  total += pow(2, counter)
  counter += 1
```

Beware infinite loops

Uh oh..

```
counter = 1
while counter < 5:
    total += pow(2, counter)
```

What one line of code would fix this?

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counter = 1
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What one line of code would fix this?

`counter += 1`

Beware infinite loops

Uh oh..

```
counter = 1
while counter < 5:
    total += pow(2, counter)
```

What one line of code would fix this?

`counter += 1`

```
counter = 6
while counter > 5:
  total += pow(2, counter)
  counter += 1
```

How do we save this code?

Beware infinite loops

Uh oh..

```
counter = 1
while counter < 5:
    total += pow(2, counter)
```

What one line of code would fix this?

`counter += 1`

```
counter = 6
while counter > 5:
  total += pow(2, counter)
  counter += 1
```

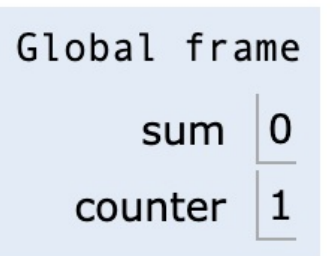
How do we save this code?

Intentions are unclear! Change the initial value and condition?

Execution of loops

1. Evaluate the header's Boolean expression.
2. If it is a true value, execute the suite of statements, then return to step 1.

```
1  sum = 0
2  counter = 0
3  while counter < 10:
4      sum += pow(counter, 2)
5      counter += 1
```

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Loops in functions

A loop in a function will commonly use a parameter to determine some aspect of its repetition.

```
def sum_up_squares(start, end):
    counter = start
    total = 0
    while counter <= end:
      total += pow(counter, 2)
      counter += 1
    return total

sum_up_squares(1, 5)
```

The break statement

To prematurely exit a loop, use the `break` statement:

```
counter = 100
while counter < 200:
    if counter % 7 == 0:
        first_multiple = counter
        break
    counter += 1
```

View in PythonTutor

Looping while true

If you are brave, you can write while loops like this:

```
counter = 100
while True:
    if counter % 62 == 0:
        first_multiple = counter
        break
    counter += 1
```

⚠ Be very sure that you're not coding an infinite loop!

Don't trust me? Ask Twitter!

Exercise

These are un-graded exercises you can do after the lecture to make sure you grok the basics:

- count_evens()
- count_multiples()
- sum_multiples()
- product_of_numbers()

Example: Prime factors

A **prime number** is an integer greater than 1 whose only factors are 1 and the number itself (e.g., 3, 5, 7, 11).

```
def is prime(n):
    """Return True iff N is prime."""
    return n > 1 and smallest factor(n) == n

def smallest factor(n):
    """Returns the smallest value k>1 that evenly divides N."""
    ???

def print factors(n):
    """Print the prime factors of N."""
    ???
```

Let's implement them together.