CSCI 141

Lecture 12:
More turtles
Opening the black box: introduction to functions

Announcements

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- Bring your questions to Wednesday's lecture - QOTDs, coding questions, etc.

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- Exam material: range(functions)

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- Exam material: range(functions)
  - that is, 0 up to but not including writing your own functions (this should be partway through today's lecture)

Goals

- Be able to write programs that make turtles draw simple shapes
- Be able to choose which type of loop (while or for) is best for a given problem.
- Know the syntax for defining your own functions
- Know how to define and use functions that take no arguments and return no values
- Know how to define use parameters to refer to the input arguments of a function

QOTD

```python
for i in range(4):
    for j in range(3, 6):
        print("*", end =" ")
    print()
```

QOTD

```python
v = 1
for i in range(1, 6):
    v = v * i
```

Which of the following programs end with v having the same value as the program above?

Program A:

```python
v = 1
i = 0
while i < 5:
    i += 1
    v = v * i
```

QOTD

```
v = 1
for i in range(1, 6):
    v = v * i
```

Which of the following programs end with v having the same value as the program above?

Program B:

```
v = 2
for i in range(1, 5):
    v = v * i
```

QOTD

```
v = 1
for i in range(1, 6):
    v = v * i
```

Which of the following programs end with v having the same value as the program above?

Program C:

```
v = 1
for i in range(5):
    v = v * (i + 1)
```

QOTD

```
v = 1
for i in range(1, 6):
    v = v * i
```

Which of the following programs end with v having the same value as the program above?

Program D:

```
v = 1
i = 1
while i <= 5:
    v = v * i
    i += 1
```

A question about `for` loops

```
for value in [1, 16, 4]:
    print(value)
    value = value * 10
```

(for_quirk.py)

Last time: Turtles!

Last time: Turtles!

Creating and Using Objects

```
import turtle
scott = turtle.Turtle()
```

What is this about?

No new syntax here:
We import a module called `turtle`
that has a function called `Turtle`

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what **is** an object? what can it **do**?

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(whiteboard: diagram of assignment statement)

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# move the turtle forward 10 units:
scott.forward(10)
# turn the turtle left 90 degrees:
scott.left(90)
```

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functions that belong to an object are called its methods

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functions that belong to an object are called its methods

What methods do Turtles have? Lots!
Check the docs:
https://docs.python.org/3.3/library/turtle.html?highlight=turtle

Modules vs Objects

```python
import random
num = random.randint(0,9)
```

```python
import turtle
scott = turtle.Turtle()
scott.forward(100)
```

Modules vs Objects

import a module →

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import turtle
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Modules vs Objects

import a module →

call one of its functions →

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import a module →

call one of its functions which creates an object →

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import a module → call one of its functions →

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import a module → call one of its functions which creates an object → call one of that object's methods →

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Modules vs Objects

import a module → `import random`

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import random
num = random.randint(0,9)
```

import a module

call one of its functions which creates an object

call one of that object's methods

```
import turtle
scott = turtle.Turtle()
scott.forward(100)
```

Demo: make more than one `turtle`

Algorithms with Turtles

Task: Write pseudocode for an algorithm to draw a square with side length 100:

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```
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```

Algorithms with Turtles

Task: Write pseudocode for an algorithm to draw a square with side length 100:

```
1. Move forward 100
2. Turn left 90 degrees
```

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1. Move forward 100
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3. Move forward 100
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2. Turn left 90 degrees
3. Move forward 100
4. Turn left 90 degrees
```

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5. Move forward 100
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```
1. Move forward 100
2. Turn left 90 degrees
3. Move forward 100
4. Turn left 90 degrees
5. Move forward 100
6. Turn left 90 degrees
```

Algorithms with Turtles

Task: Write pseudocode for an algorithm to draw a square with side length 100:

```
1. Move forward 100
2. Turn left 90 degrees
3. Move forward 100
4. Turn left 90 degrees
5. Move forward 100
6. Turn left 90 degrees
7. Move forward 100
```

Algorithms with Turtles

Task: Write pseudocode for an algorithm to draw a square with side length 100:

```
1. Move forward 100
2. Turn left 90 degrees
3. Move forward 100
4. Turn left 90 degrees
5. Move forward 100
6. Turn left 90 degrees
7. Move forward 100
8. (Turn left 90 degrees)
```

Algorithms with Turtles

Task: Write pseudocode for an algorithm to draw a square with side length 100:

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2. Turn left 90 degrees
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4. Turn left 90 degrees
5. Move forward 100
6. Turn left 90 degrees
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```

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2. Turn left 90 degrees
3. Move forward 100
4. Turn left 90 degrees
5. Move forward 100
6. Turn left 90 degrees
7. Move forward 100
8. (Turn left 90 degrees)
```

Can we do better?

Algorithms with Turtles

Task: Write pseudocode for an algorithm to draw a square with side length 100:

```
Repeat 4 times:
    1.  move forward 100
    2.  turn left 90
```

Algorithms with Turtles

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Repeat 4 times:
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Demo

Demo

- turtle_for.py: Create a turtle and draw a square with a for loop
- turtle_while.py: Create a turtle and draw a square with a while loop

`while` **vs** `for`

Are for loops **always** better?

`while` vs `for`

Task: Generate and print random integers between 1 and 10 (inclusive) until one of the random numbers exceeds 8.

Would you use a `for` loop or a `while` loop?

`while` vs `for`

Task: Ask the user for a number (**n**), then print 100 random numbers between 0 and **n**.

Would you use a `for` loop or a `while` loop?

`while` vs `for`

Task: Sum the numbers from 1 to 340, leaving out those divisible by 5.

Would you use a `for` loop or a `while` loop?

Functions, Revisited

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- We’ve been using functions since day 1:

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print("Hello, World!")
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  `print`, `input`, `type`, `len`, `int`, `str`, ...

Functions, Revisited

- We’ve been using functions since day 1:

```
print("Hello, World!")
```

- Built-in functions so far:
  `print`, `input`, `type`, `len`, `int`, `str`, ...

- We can import more functions:

```
import math
import turtle
math.sqrt(4)
turtle.Turtle()
```

Functions, Revisited

What **is** a function, anyway?

```
print("Hello world")
```

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- It *may* do something that has an **effect**

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```
print("Hello world")
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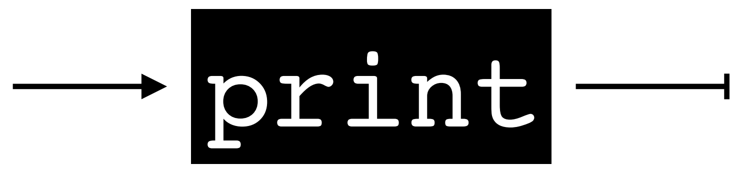
Input(s):

- 0 or more values
- (optional) sep and end keywords



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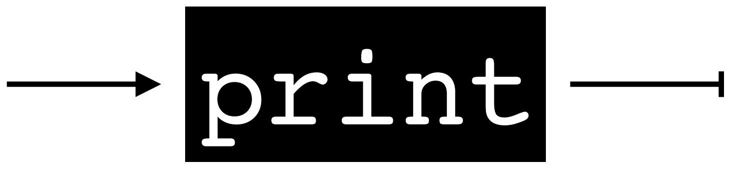

Return value:

- none

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- It *may* do something that has an **effect**
- It *may* return a value

```
print("Hello world")
```

Input(s):

- 0 or more values
- (optional) sep and end keywords

Return value:

- none

Effects: prints arguments to the screen, with given separator and end

Functions, Revisited

What **is** a function, anyway?

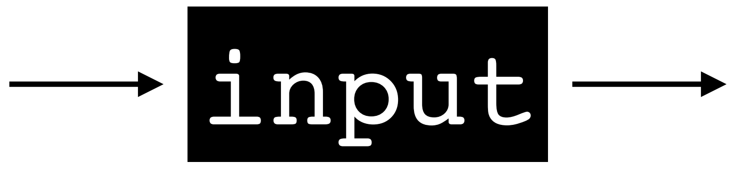
It’s a chunk of code with a name.

- It *may* take arguments as input
- It *may* do something that has an effect
- It *may* return a value

```
input(“Enter a number:”)
```

Input(s):

- none, or
- a string to print as a prompt



Return value:

- the input from the user

Effects: prompts for user input and reads it from the keyboard

Functions, Revisited

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- It *may* take arguments as input
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- It *may* return a value

```
type(6/2)
```

Input(s):

- a value

$$\begin{tikzcd} {} \arrow[r] & \boxed{\texttt{type}} \arrow[r] & {} \end{tikzcd}$$

Return value:

- the type of the value

Effects: none

Functions, Revisited

What **is** a function, anyway?

It's a chunk of code with a name.

- It *may* take arguments as input
- It *may* do something that has an effect
- It *may* return a value

```
math.sin(math.pi/2)
```

Input(s):

- a number

$$\longrightarrow \boxed{\texttt{math.sin}} \longrightarrow$$

Return value:

- the sine of the value

Effects: none

Functions, Revisited

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Input(s):

- a number

Return value:

- none

$$\longrightarrow \boxed{\texttt{scott.forward}} \longrightarrow\!|$$

Effects: moves the turtle forward by the given number of units

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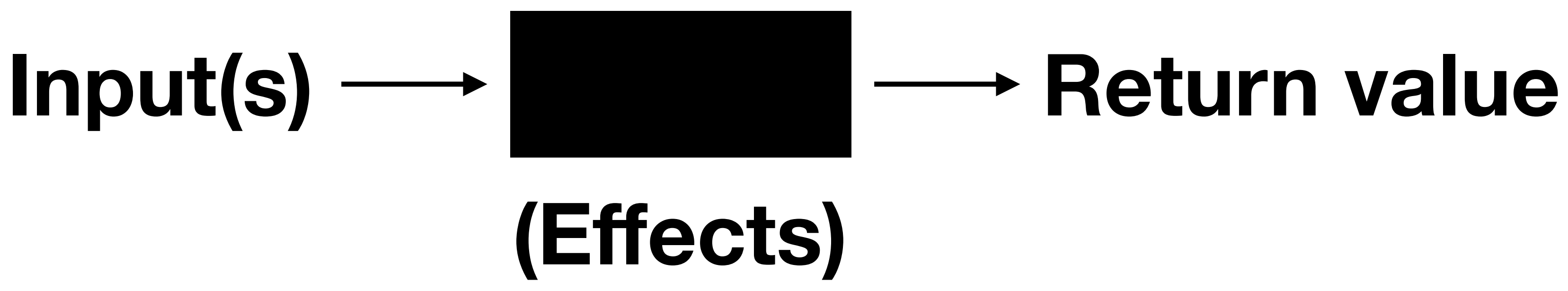

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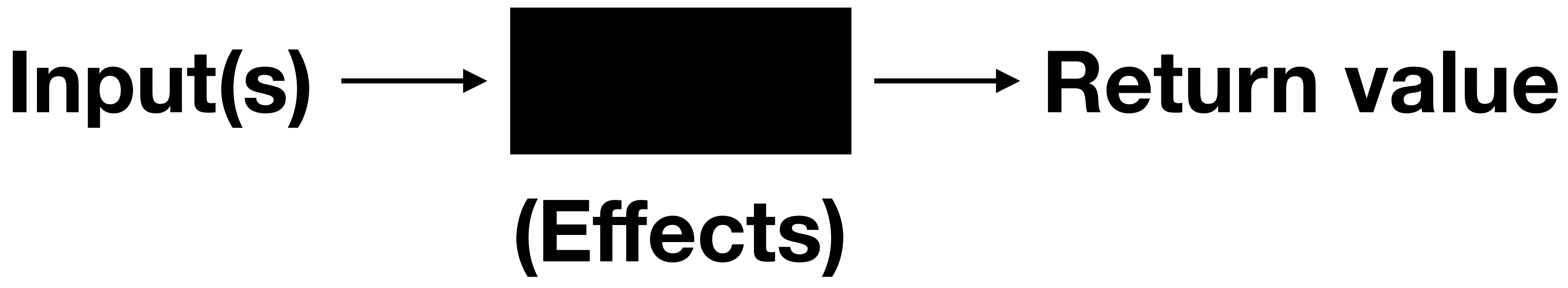

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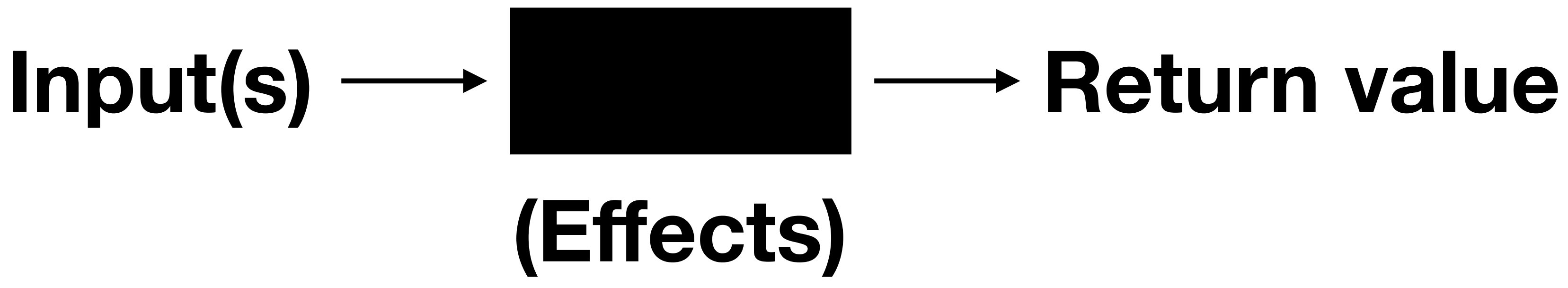

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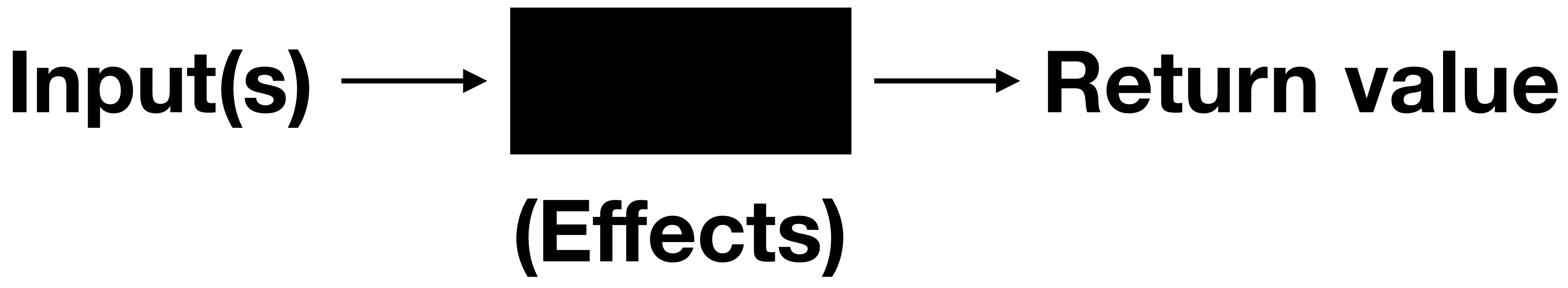

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\textbf{Input(s)} \arrow[r] & \blacksquare \arrow[r] & \textbf{Return value} \\
& \textbf{(Effects)} &
\end{tikzcd}$$

This is a **great** situation to be in!

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$$\begin{tikzcd}
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 & \textbf{(Effects)} &
\end{tikzcd}$$

This is a **great** situation to be in!

A bunch of (complicated), powerful stuff is wrapped up in a nice, easy-to-use package.

What if

You want a nice easy-to-use function that does something complicated, but **nobody else has written it for you…**

What if

You want a nice easy-to-use function that does something complicated, but **nobody else has written it for you…**

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Soon, you will have the **power** to write your **own** functions.

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Writing Functions: Syntax

```
def name(parameters):
    statements
```

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Two important questions:

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Two important questions:

1. How does the function use the arguments (inputs) passed to it?

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Two important questions:

1. How does the function use the arguments (inputs) passed to it?
2. How does the function return a value?

Let’s **dodge** these questions for a moment…

Functions: the simplest kind

No arguments, no return value:

```
def name():
    statements
```

Example:

```
def print_hello():
    print("Hello, world!")
```

Demo

- hello_fn.py

Demo

- print_hello
- definition does nothing except make the function exist
- call it
- can call it whenever/however many times
- can’t call it before it’s defined

Demo: Function to print a rectangle of # symbols

Input(s):

- none

`print_rectangle`

Return value:

- none

Effects: prints a 2x50 rectangle of #s to the screen

Demo: Function to print a rectangle of # symbols

- executing a def statement (function definition) has no effect except defining that function.
- after it is defined, a function can be used whenever and wherever in the program
- modify to ask user what character to print

Writing Functions: Syntax

```
def name(parameters):
    statements
```

Two important questions:

1. **How does the function use the arguments (inputs) passed to it?**
2. How does the function return a value?

Let’s **dodge** these questions for a moment…

Writing Functions: Syntax

1. How does the function use the arguments (inputs) passed to it?

`def` keyword

function name

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Writing Functions: Syntax

1. How does the function use the arguments (inputs) passed to it?

`def` keyword

function name

```
def name(parameters):
    statements
```

inputs

comma-separated list of parameters: variable names that will refer to the input arguments

Demo: Function to print a rectangle of a symbol passed in as an argument.

Input(s):

- character to make a rectangle out of

Return value:

- none

$\longrightarrow$ `print_rectangle` $\longmapsto$

Effects: prints a 2x50 rectangle of the given character to the screen

Writing Functions: Syntax

1. How does the function use the arguments (inputs) passed to it?

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comma-separated list of parameters: variable names that will refer to the input arguments

Inside the function, the parameters act as **local variables** that refer to the arguments passed into the function.

Demo: Function to draw a square using a turtle