Functions

Reusing Code

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Sometimes, you want to run the same block of commands and multiple different locations in your code.

Can't just use a for-loop since these locations may be separated by a region of code that you only want to execute once.

Reusing Code

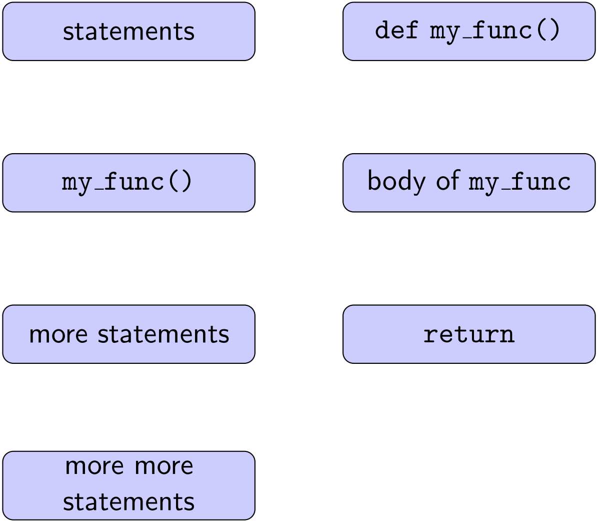
```
print("Instructions:")
print("Pick a digit between 1 and 10")
print("Don’t tell your opponent what you picked")
player1 = int(input("Player 1:  enter pick here:  "))
print("Instructions:")
print("Pick a digit between 1 and 10")
print("Don’t tell your opponent what you picked")
player2 = int(input("Player 2:  enter pick here:  "))
if player2 == player1:
    print("Player 2 wins!!!")
else:
    print("Player 1 wins!!!")
```

Reusing Code

```
def instructions():
    print("Instructions:")
    print("Pick a digit between 1 and 10")
    print("Don’t tell your opponent what you picked")

instructions()
player1 = int(input("Player 1:  enter pick here:  "))
instructions()
player2 = int(input("Player 2:  enter pick here:  "))
if player2 == player1:
    print("Player 2 wins!!!")
else:
    print("Player 1 wins!!!")
```

Function Control Flow



statements

my_func()

more statements

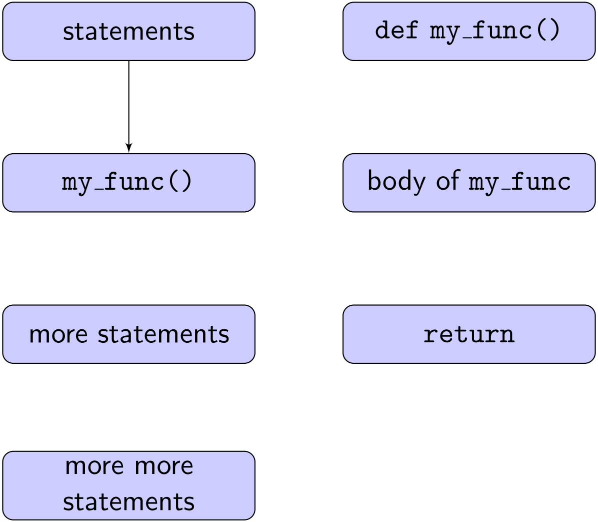
more more statements

def my_func()

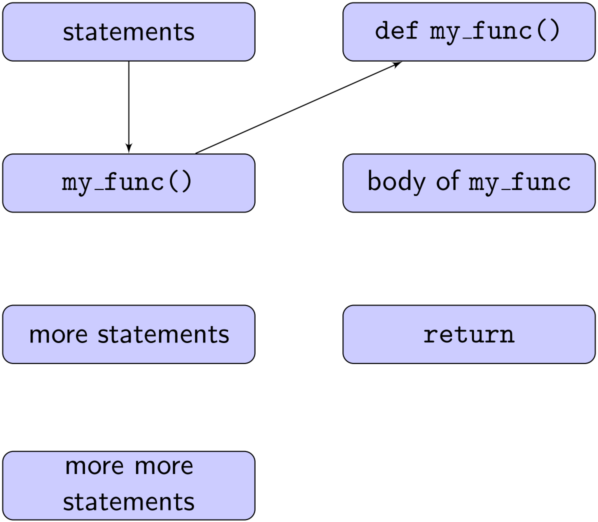
body of my_func

return

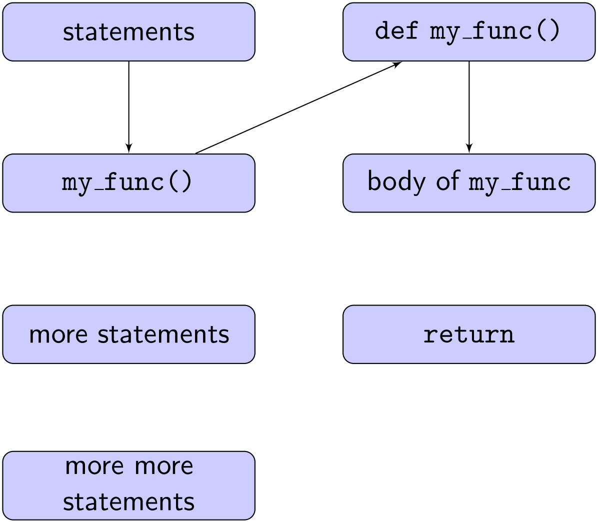
Function Control Flow



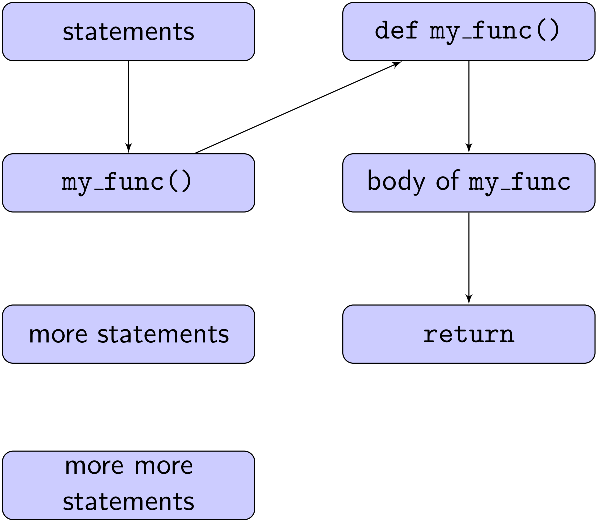
Function Control Flow



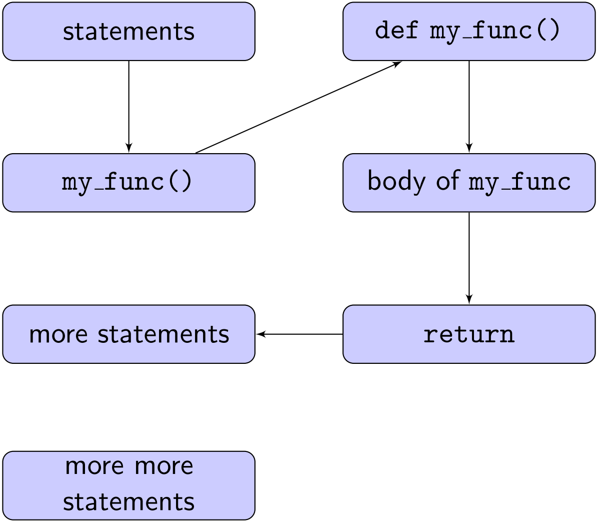
Function Control Flow



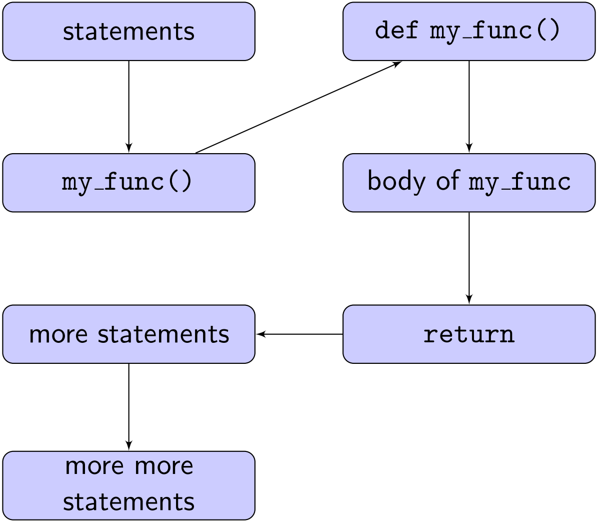
Function Control Flow



Function Control Flow



Function Control Flow



Garbage Collector

Actual footage of a real-life variable being released:

```
>>> x = 1
>>> x = 2
>>> x = x + 1
>>> _
```

Memory:

Address	Contents
00000000	01101011
00000001	11001100
x	00000011
00000011	10101110
⋮	⋮
11111111	00100000

Garbage Collector

Actual footage of a real-life variable being released:

```
>>> x = 1
>>> x = 2
>>> x = x + 1
>>> quit()
```

Memory:

Address	Contents
00000000	01101011
00000001	11001100
00000010	00000011
00000011	10101110
⋮	⋮
11111111	00100000

Garbage Collector

Actual footage of a funcion return:

```
def my_func():
    x = 2
    x = x + 1
    return
```

Memory:

Address	Contents
00000000	01101011
00000001	11001100
00000010	00000011
00000011	10101110
⋮	⋮
11111111	00100000

Concept Check!

What is printed by each of the following?

1.
```
x = 0
def my_func():
    x = 1
    print(x)
    return

my_func()
```

2.
```
x = 0
def my_func():
    x = 1
    return

my_func()
print(x)
```

Concept Check!

What is printed by each of the following?

1.
```
x = 0
def my_func():
    x = 1
    print(x)
    return

my_func()
```

1

2.
```
x = 0
def my_func():
    x = 1
    return

my_func()
print(x)
```

Concept Check!

What is printed by each of the following?

1.
   ```
   x = 0
   def my_func():
       x = 1
       print(x)
       return

   my_func()
   ```

   ```
   1
   ```

2.
   ```
   x = 0
   def my_func():
       x = 1
       return

   my_func()
   print(x)
   ```

   ```
   0
   ```

Function I/O

Function I/O

```
def my_func(a, b):
    x = a + b
    y = a - b
    return x, y
```

Function I/O

parameters

↓ ↓

```
def my_func(a, b):
    x = a + b
    y = a - b
    return x, y
```

Function I/O

```
          parameters
            ↓  ↓
def my_func(a, b):
    x = a + b
    y = a - b
    return x, y  ←return statement
```

Function I/O

```
        parameters
            ↓  ↓
def my_func(a, b):
    x = a + b
    y = a - b
    return x, y  ←return statement
```

```
out1, out2 = my_func(3, 2)
```

Function I/O

```
        parameters
            ↓  ↓
def my_func(a, b):
    x = a + b
    y = a - b
    return x, y  ←return statement

return values      arguments
  ↓    ↓             ↓  ↓
out1, out2 = my_func(3, 2)
```

Function I/O

```
        parameters
            ↓  ↓
def my_func(a, b):
    x = a + b
    y = a - b
    return x, y  ←return statement

return values     arguments
  ↓    ↓             ↓  ↓
out1, out2 = my_func(3, 2)
print(out1) # prints 5
```

Function I/O

```
        parameters
            ↓  ↓
def my_func(a, b):
    x = a + b
    y = a - b
    return x, y  ←return statement

return values          arguments
  ↓    ↓                 ↓  ↓
out1, out2 = my_func(3, 2)
print(out1) # prints 5
print(out2) # prints 1
```

Algebra Functions

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$$f(x) = 3x^2 + 2x + 1$$

Algebra Functions

$$f(x) = 3x^2 + 2x + 1$$

$$f(2)$$

Algebra Functions

$$f(x) = 3x^2 + 2x + 1$$

$$f(2) = 17$$

Mini-program

Mini-program

```
          parameters
            ↓   ↓
def my_func(a, b):
    x = a + b
    y = a - b
    return x, y   ←return statement
```

Mini-program

parameters

↓ ↓

```
def my_func(a, b):
    x = a + b
    y = a - b
    return x, y
```

←*return statement*

parameters = inputs

Mini-program

```
            parameters
               ↓  ↓
def my_func(a, b):
    x = a + b
    y = a - b
    return x, y  ←return statement
```

parameters = inputs

body = calcualtions

Mini-program

```
        parameters
            ↓   ↓
def my_func(a, b):
    x = a + b
    y = a - b
    return x, y   ←return statement
```

parameters = inputs

body = calcualtions

return values = prints

Familiar Functions

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- `input(x)` – receives input message `x`, returns user's input
- `str(x)/int(x)/float(x)` – receives variable `x`, returns converted value of `x`

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- `print(x, y, ...)` – receives 0 or more in inputs, returns nothing
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- `range(n)` – receives input `n`, returns a generator

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- `input(x)` – receives input message `x`, returns user's input
- `str(x)/int(x)/float(x)` – receives variable `x`, returns converted value of `x`
- `range(n)` – receives input `n`, returns a generator

Built-in/intrinsic functions

Pass-by-Reference

```
def ref_func(x):
    x = x + 1
    return

y = 1
ref_func(y)

y =  ?
```

Pass-by-Reference

```
def ref_func(x):
    x = x + 1
    return

y = 1
ref_func(y)

y =  ?
```

Memory:

Address	**Contents**
00000000	01101011
00000001	11001100
y	00000001
00000011	10101110
⋮	⋮
11111111	00100000

Pass-by-Reference

```
def ref_func(x):
    x = x + 1
    return

y = 1
ref_func(y)

y =  ?
```

Memory:

Address	**Contents**
00000000	01101011
00000001	11001100
y , **x**	00000001
00000011	10101110
⋮	⋮
11111111	00100000

Pass-by-Reference

```
def ref_func(x):
    x = x + 1
    return

y = 1
ref_func(y)

y =  ?
```

Memory:

Address	**Contents**
00000000	01101011
00000001	11001100
y , x	**00000010**
00000011	10101110
⋮	⋮
11111111	00100000

Pass-by-Reference

```
def ref_func(x):
    x = x + 1
    return

y = 1
ref_func(y)

y =  ?
```

Memory:

Address	Contents
00000000	01101011
00000001	11001100
y	**00000010**
00000011	10101110
⋮	⋮
11111111	00100000

Pass-by-Reference

```
def ref_func(x):
    x = x + 1
    return

y = 1
ref_func(y)

y =  2
```

Memory:

Address	**Contents**
00000000	01101011
00000001	11001100
y	**00000010**
00000011	10101110
⋮	⋮
11111111	00100000

Pass-by-Value

```
def value_func(x):
    x = x + 1
    return

y = 1
value_func(y)

y =  ?
```

Pass-by-Value

```
def value_func(x):
    x = x + 1
    return

y = 1
value_func(y)

y =  ?
```

Memory:

Address	**Contents**
00000000	01101011
00000001	11001100
y	00000001
00000011	10101110
⋮	⋮
11111111	00100000

Pass-by-Value

```
def value_func(x):
    x = x + 1
    return

y = 1
value_func(y)

y =  ?
```

Memory:

Address	**Contents**
00000000	01101011
00000001	11001100
y	00000001
x	**00000001**
⋮	⋮
11111111	00100000

Pass-by-Value

```
def value_func(x):
    x = x + 1
    return

y = 1
value_func(y)

y =  ?
```

Memory:

Address	**Contents**
00000000	01101011
00000001	11001100
y	00000001
x	**00000010**
⋮	⋮
11111111	00100000

Pass-by-Value

```
def value_func(x):
    x = x + 1
    return

y = 1
value_func(y)

y =  ?
```

Memory:

Address	**Contents**
00000000	01101011
00000001	11001100
y	00000001
00000011	00000010
⋮	⋮
11111111	00100000

Pass-by-Value

```
def value_func(x):
    x = x + 1
    return

y = 1
value_func(y)

y =  1
```

Memory:

Address	**Contents**
00000000	01101011
00000001	11001100
y	00000001
00000011	00000010
⋮	⋮
11111111	00100000

Tradeoffs

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Some programming languages use pass-by-reference and others use pass-by-value

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Don't try to reassign parameter values

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Some programming languages use pass-by-reference and others use pass-by-value

- Pass-by-reference is more efficient
- Pass-by-value is safer and easier for programmers to use

Python uses a bit of both.

Behaves more like pass-by-value in most cases.

Don't try to reassign parameter values (until we get to OOP)

Concept Check!

What is printed by the following code?

1.
   ```
   def f(x):
       y = x * x
       return y

   print(f(5))
   ```

2.
   ```
   def f(x, y, z):
       a = x + y + z
       b = x * y * z
       return a, b

   x = 3
   out1, out2 = f(2, x, 4)
   print(out1)
   print(out2)
   ```

Concept Check!

What is printed by the following code?

1.
```
def f(x):
    y = x * x
    return y

print(f(5))
```

25

2.
```
def f(x, y, z):
    a = x + y + z
    b = x * y * z
    return a, b

x = 3
out1, out2 = f(2, x, 4)
print(out1)
print(out2)
```

Concept Check!

What is printed by the following code?

1.
```
def f(x):
    y = x * x
    return y

print(f(5))
```

25

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```
def f(x, y, z):
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    return a, b

x = 3
out1, out2 = f(2, x, 4)
print(out1)
print(out2)
```

9

Concept Check!

What is printed by the following code?

1.
```
def f(x):
    y = x * x
    return y

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```

25

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```
def f(x, y, z):
    a = x + y + z
    b = x * y * z
    return a, b

x = 3
out1, out2 = f(2, x, 4)
print(out1)
print(out2)
```

9
24

Procedural Programming

Procedural Programming

```
statement1
statement2
statement3
    ⋮
```

Procedural Programming

```
statement1
statement2
statement3
    ⋮
statement1000
```

Procedural Programming

```
statement1
statement2
statement3
    ⋮
statement1000
```

- Hard to test and debug!

Procedural Programming

```
statement1
statement2
statement3
    ⋮
statement1000
```

- Hard to test and debug!
- What if someone wants to use just part of your code?

Procedural Programming

```
statement1
statement2
statement3
    ⋮
statement1000
```

- Hard to test and debug!
- What if someone wants to use just part of your code?
- What if you need to change something small on line 500?

Procedural Programming

Procedural Programming

```
def func1(x, y):
    statement1
    statement2
        ⋮
    return z

def func2():
    statement50
    statement51
        ⋮
    return

    ⋮
```

Procedural Programming

```
def func1(x, y):
    statement1
    statement2
        ⋮
    return z

def func2():
    statement50
    statement51
        ⋮
    return

    ⋮
```

```
a few input statements
out1 = func1(input1,
input2)
func2()
out2 = func3(out1)
    ⋮
```

Procedural Programming

```
def func1(x, y):
    statement1
    statement2
        ⋮
    return z
def func2():
    statement50
    statement51
        ⋮
    return

    ⋮
```

```
a few input statements
out1 = func1(input1,
input2)
func2()
out2 = func3(out1)
    ⋮
print(func10(out9, out10))
```

Modularity

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- Assemble modules to build full solution

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Procedural programs embody the engineering principle of *modularity*:

- Break a problem up into smaller problems
- Build individual modules to solve each smaller problem
- Assemble modules to build full solution
- Individual modules should have a standardized interface, so that they are easily interchangable or replacable