CSCI 141

Lecture 16

How to approach A4, or:
Managing Complexity with Functions

Tuples

Announcements

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- Midterm grades should be out by the end of the weekend.

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- I'm working my way through the mid-quarter eval feedback. I'll discuss findings on Monday.

Goals

- Understand the task assigned in A4 and how to approach it.
- Understand how to use function composition to express complicated computations as clearly and simply as possible.
- Understand the basic usage of tuples:
    - using tuples to return multiple values from a function
    - packing and unpacking via the assignment operator

First: An Apology

Last lecture, I told you a lie.

First: An Apology

How to Execute Function Calls

If multiple variables exist with the same name, use the **innermost** one available.

1. Evaluate all arguments
2. Draw a local "box" inside the current "box"
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4. Execute the function body
5. When done, erase the local box

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*Global variables can be *read* but not *modified* unless you mark them as such using `global var_name` at the top of the function definition.

In this course, we will never modify global variables from inside a function and will only rarely read them.

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*Unless the function is defined inside another function or class. This won't happen in this course.

How did Scott get this wrong?

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No excuses! Shame!

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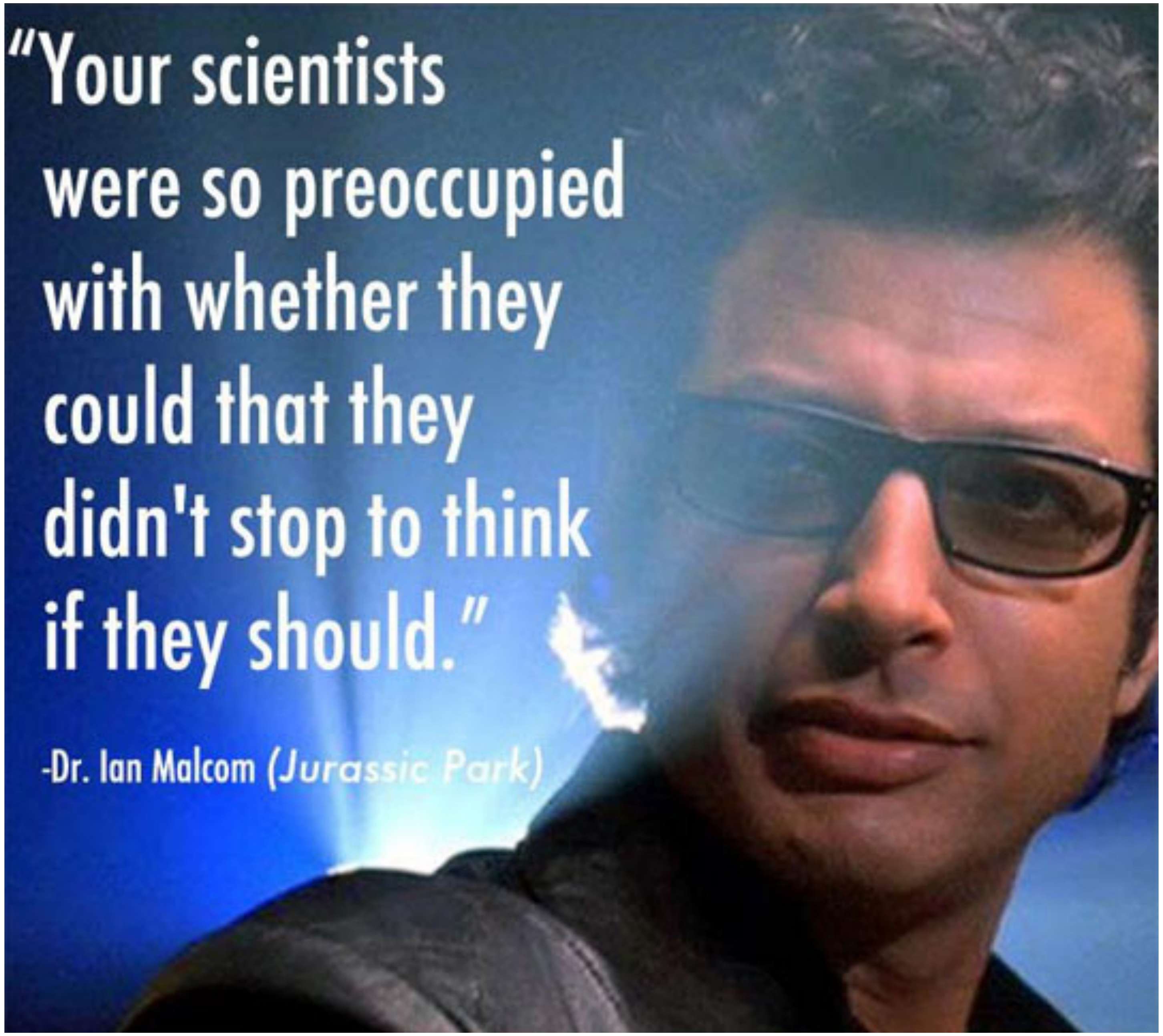

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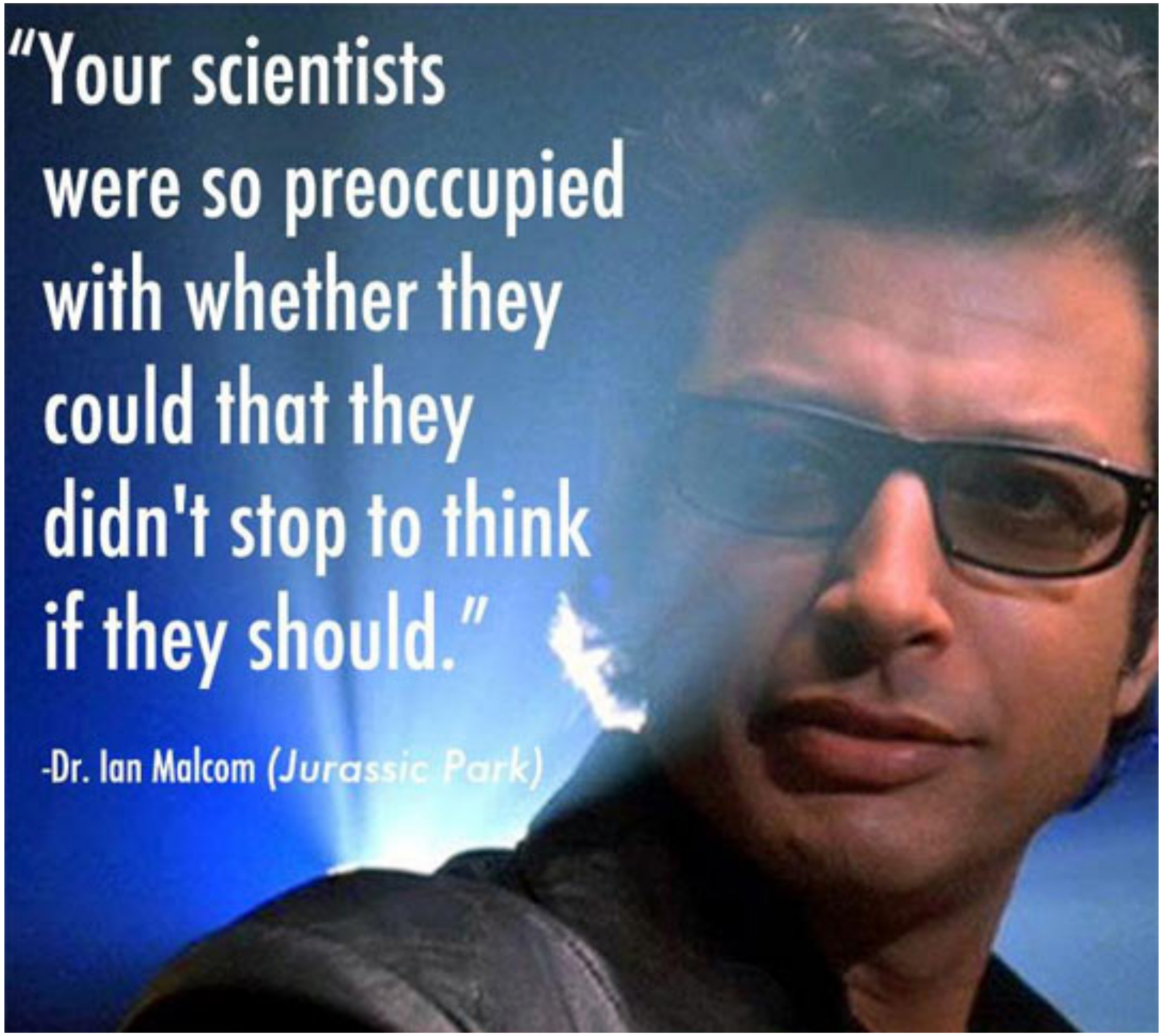
Your professor was so accustomed to doing what you **should** that he lost track of the details of what you **could**.



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The specification of the Python language says:

- You **can** access variables that are not local to the function.

Conventional software engineering wisdom says:

- You **should not** access variables that are not local to the function.

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Bottom line: If your function needs a piece of data, that data should be passed in as an argument.

Why is accessing globals bad?

- The function's behavior becomes unpredictable, because it depends on global state.
- "Pure" functions are ideal: the output is fully determined by the inputs.

Bottom line: If your function needs a piece of data, that data should be passed in as an argument.

QOTD

Which of the following belongs in a function's docstring? Select all that apply.

- Preconditions
- Postconditions
- The steps that the function takes to accomplish its task
- Information about any side-effects the function has
- Information about what arguments the function takes

One more modification

To execute a function call:

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We now know how to return a value - what does Python do with it?

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5. When done, erase the local box
6. **Replace the function call with its return value**

We now know how to return a value - what does Python do with it?

QOTD

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1. Evaluate all arguments
2. Draw a local "box" inside the global one
3. Assign argument values to parameter variables in the local box
4. Execute the function body
5. When done, erase the local box
6. **Replace the function call with its return value**

What does this program print?

```
x = 4

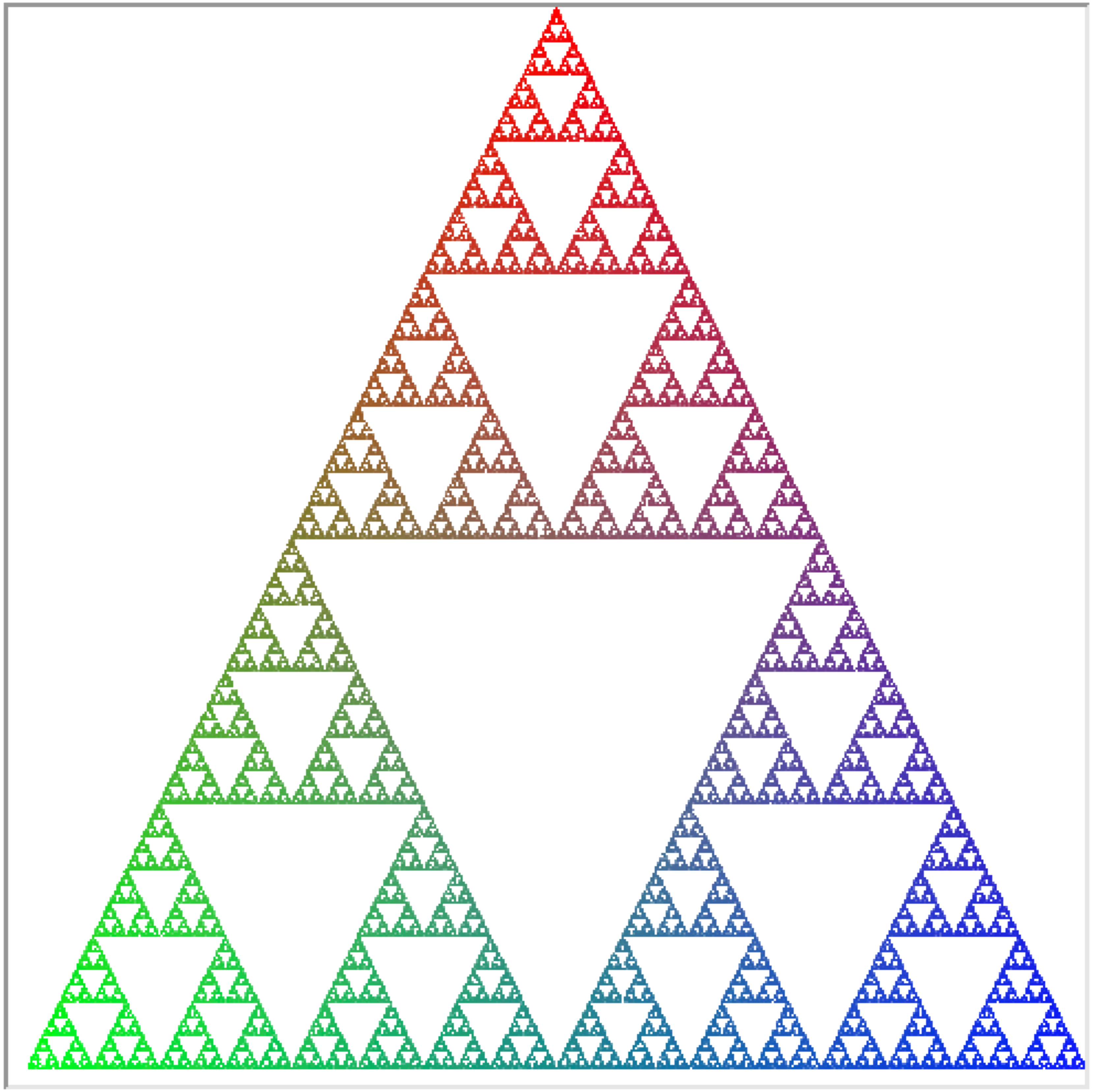
def f(x):
    return 3 * x

def g(x):
    return x + 2

print(f(g(x)))
print(g(f(x)))
```

A4

Your task:
Draw this.



A4: Pseudocode

```
# Let p be a random point in the window
# loop 10000 times:
#     c = a random corner of the triangle
#     m = the midpoint between p and c
#     choose a color for m
#     color the pixel at m
#     p=m
```

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```

Demo: break this down into manageable pieces by inventing functions that solve pieces of the problem!

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Midpoint Function

```
def midpoint(p1x, p1y, p2x, p2y):
    """ Return the midpoint between
        (p1x, p1y) and (p2x, p2y)
    """
    # code here
```

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This is **two** things!?
Can we return two things?

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    """ Return the midpoint between
        (p1x, p1y) and (p2x, p2y)
    """
    # code here
    # mid_x = . . .
    # mid_y = . . .

    return mid_x, mid_y
```

(mid_x, mid_y)

Returning Multiple Values

- You can return multiple values from a function by grouping them into a comma-separated sequence:

```
return mid_x, mid_y
```

- You can assign each to a variable when calling the function:

```
mx, my = midpoint(p1x, p1y, p2x, p2y)
```

These are actually tuples

- A tuple is a sequence of values, optionally enclosed in parens.

(of any types!)

```
(1, 4, “Mufasa”)
```

- You can “pack” and “unpack” them using assignment statements:

```
v = (1, 4, "Mufasa") # packing
(a, b, c) = v # "unpacking"
```

These are actually tuples

- Tuples can also be passed *into* functions as arguments:

```
def midpoint(p1, p2):
    """Compute the midpoint between p1 and p2"""
    p1x, p1y = p1
    p2x, p2y = p2

    # . . .
    # return mx, my
```

Tuples: Demo

Tuples: Demo

- assignment, packing, unpacking
- with and without parens (printing)
- swapping
- equality
- mismatched # values to unpack

Tuples - 1

```
a = 1
b = 2
c = 3

v = (a, a, c)

print(v, sep=" ")

# What does this print?
# A: 1 2 3
# B: 1 1 3
# C: (1, 2, 3)
# D: (1, 1, 3)
```

Tuples - 2

```
a = 1
b = 2
c = 3

a, b, c = (a, a, c)

print(a, b, c, sep=" ")

# What does this print?
# A: 1 2 3
# B: 1 1 3
# C: (1, 2, 3)
# D: (1, 1, 3)
```

Midpoint Function

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    # mid_x = . . .
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    return mid_x, mid_y
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Midpoint Function

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# mid_x = . . .
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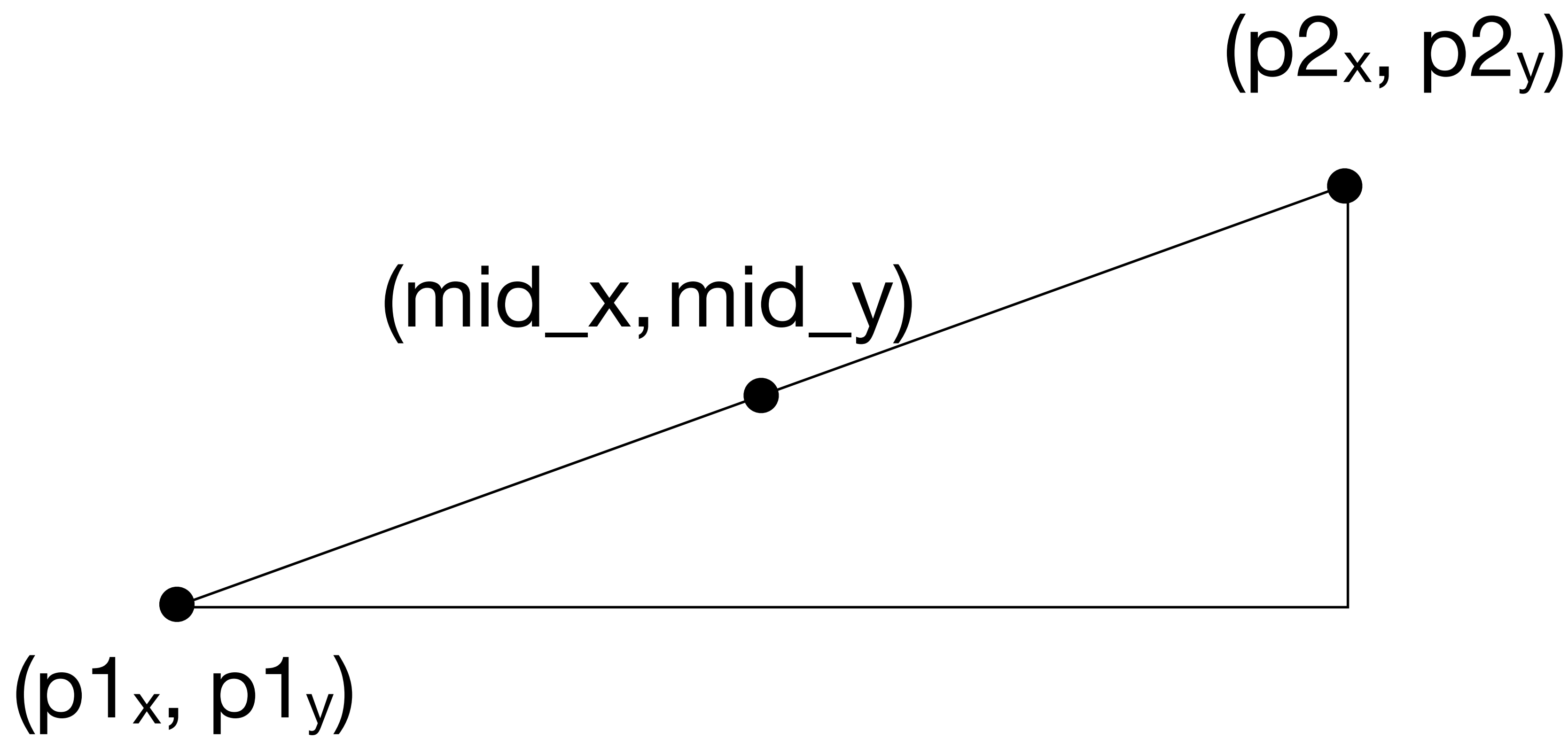
Okay, but how do you actually calculate this?



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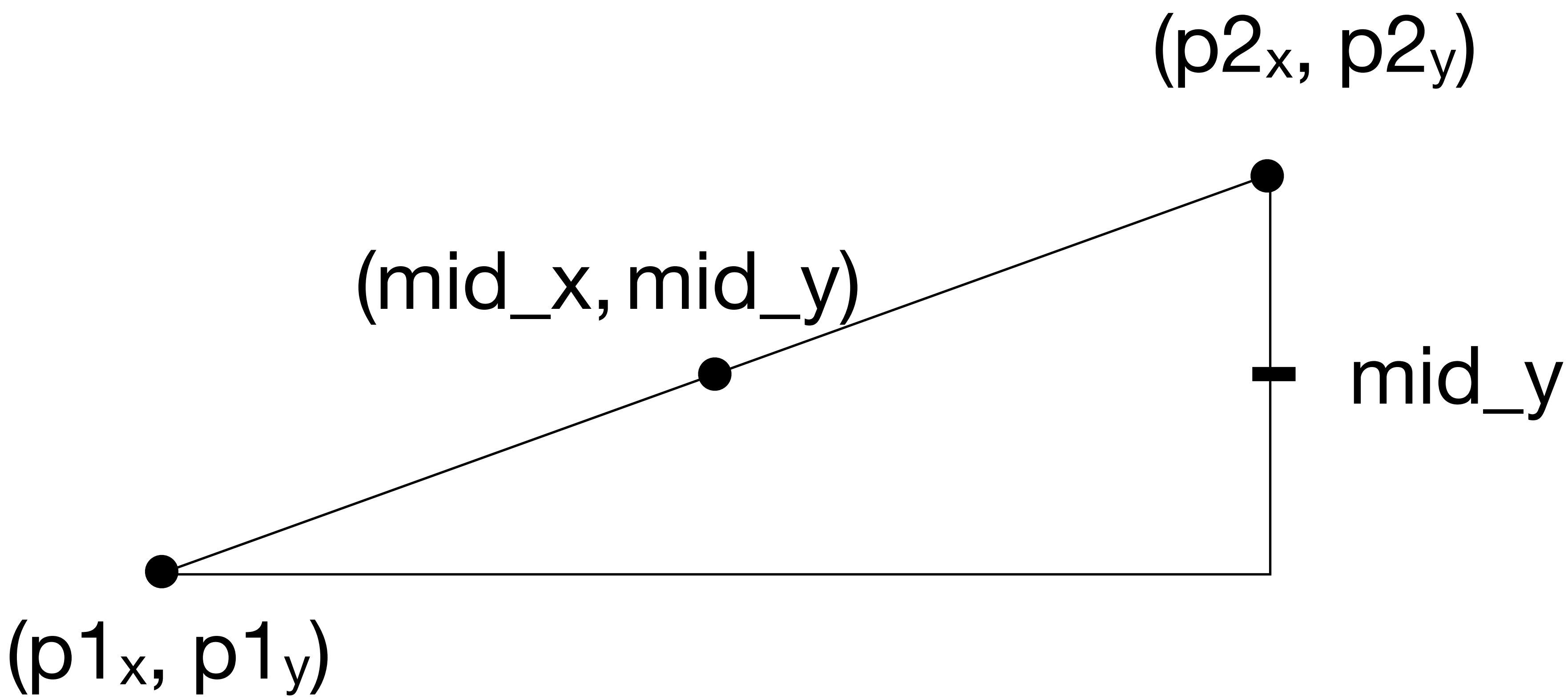

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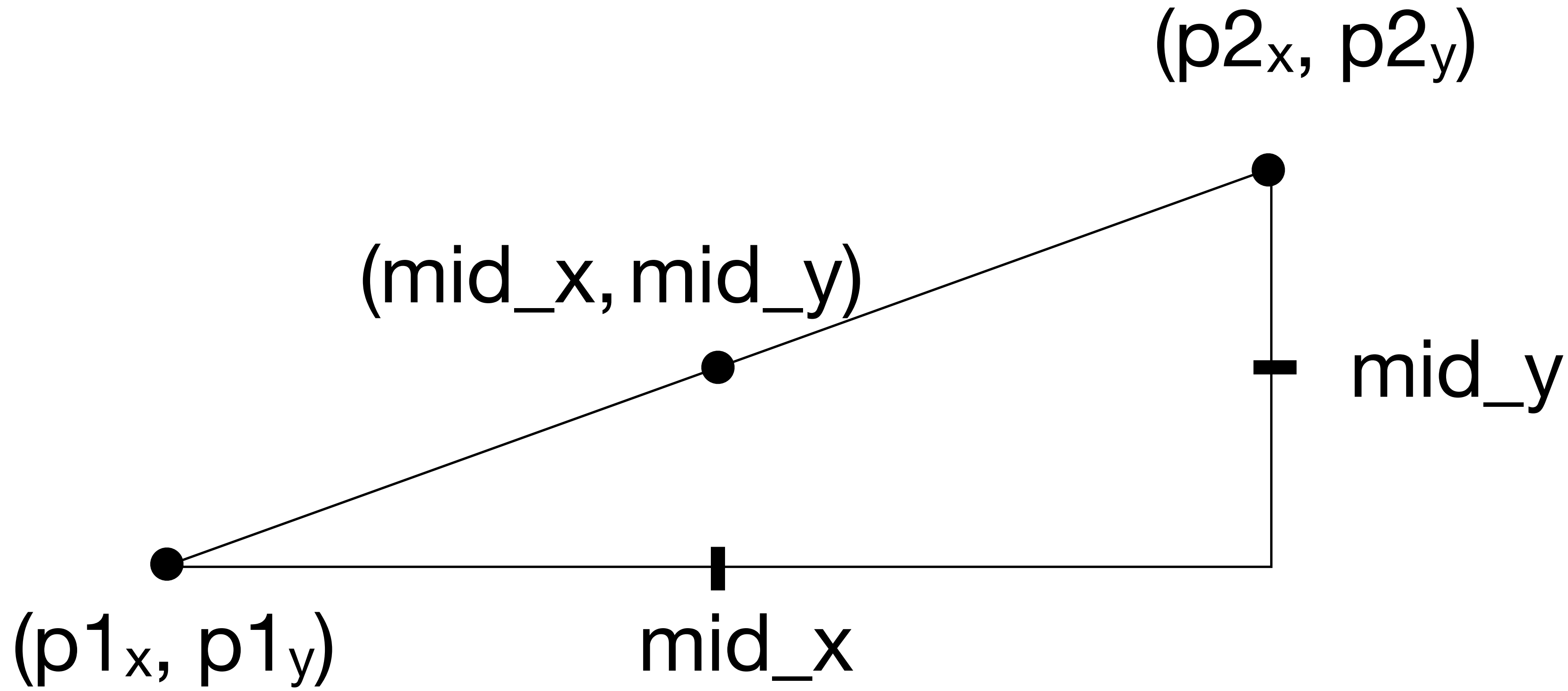

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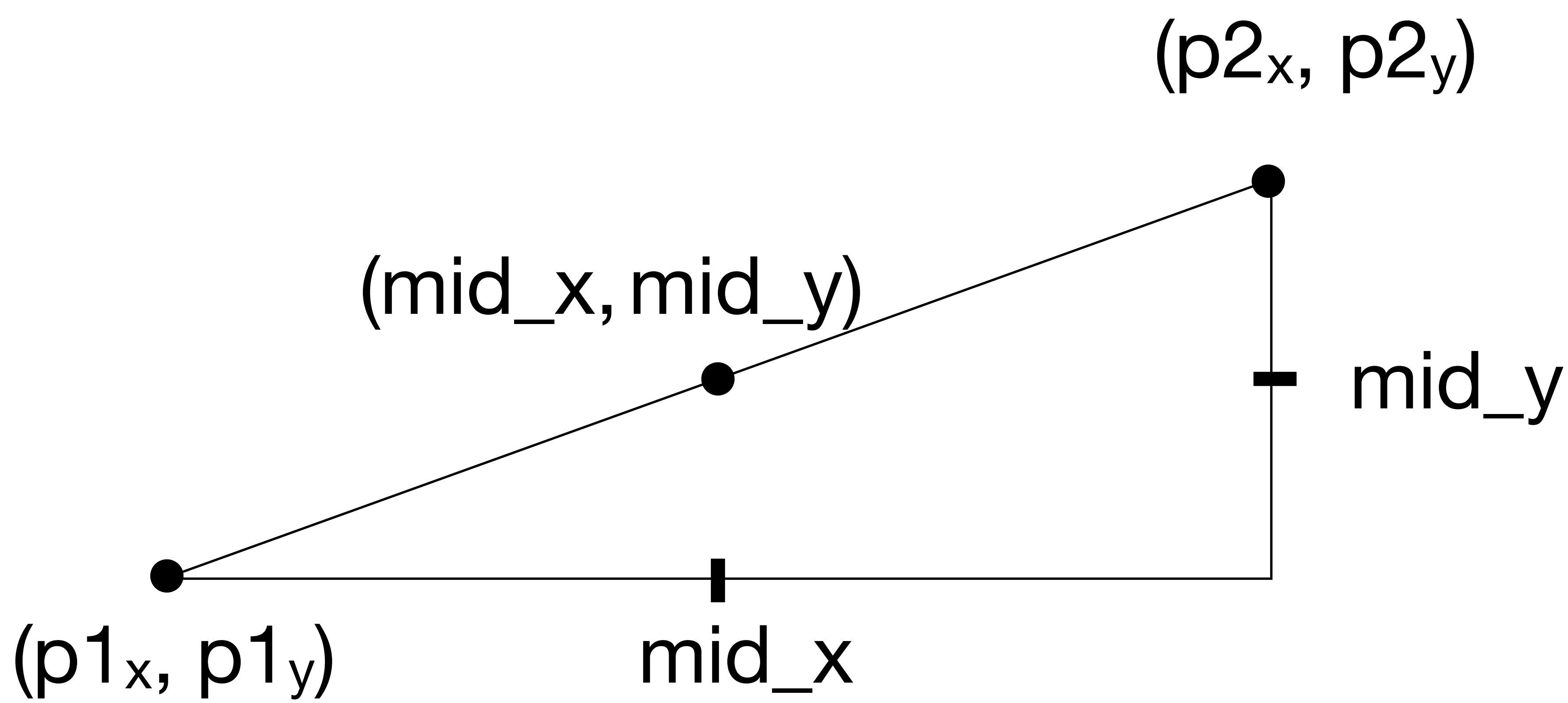

(on the board)

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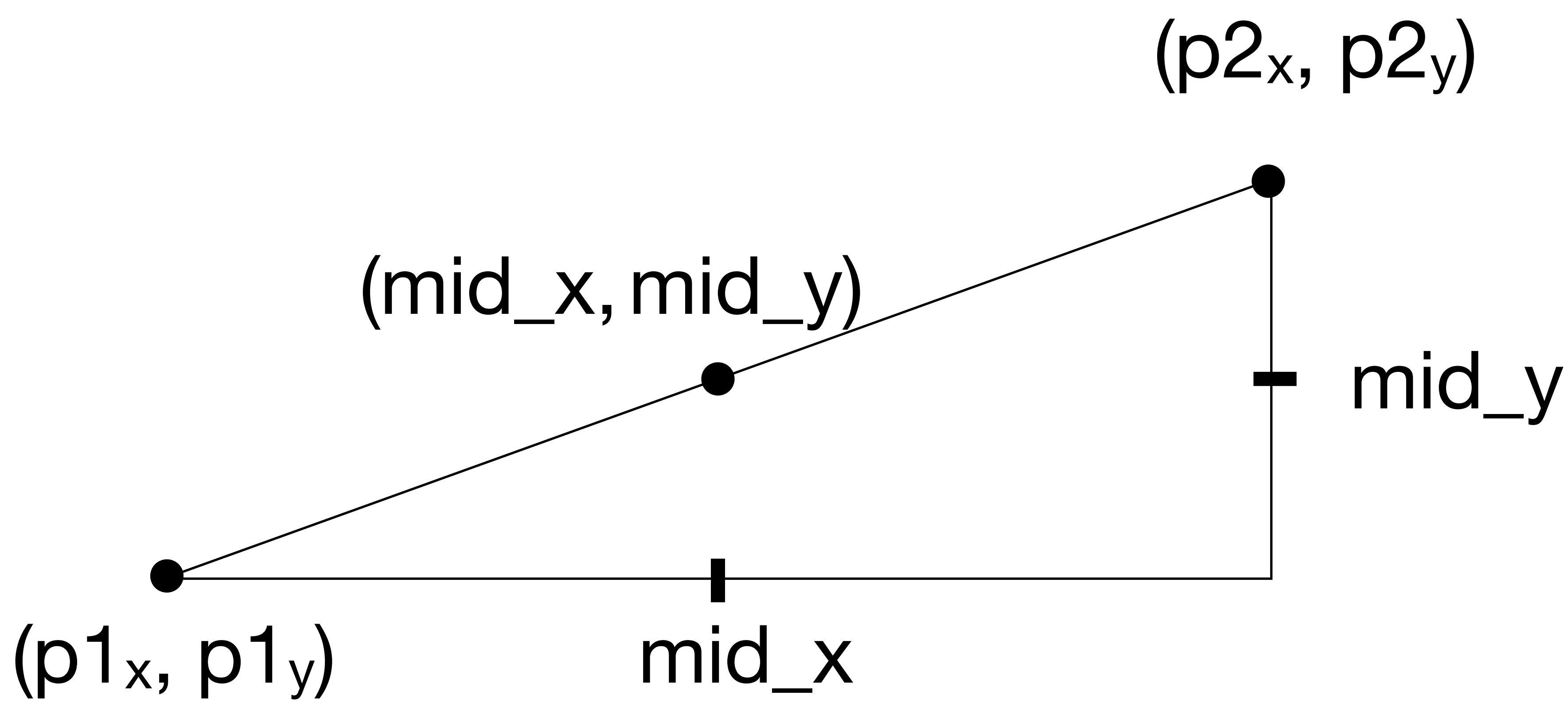

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$$mid\_x = (p1_x + p2_x) / 2$$

$$mid\_y = (p1_y + p2_y) / 2$$

Demo: writing the midpoint function

- With tuple as return value
- Switch to tuples as parameters for points

A4: Demo

```
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# loop 10000 times:
#       c = a random corner of the triangle
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#       color the pixel at m
#       p=m
```

Color is chosen based on distance from each corner.
(details on the handout)

Subproblem: compute the distance between two points.

Exercise: Implement This

on paper!

```
def distance(p1x, p1y, p2x, p2y):
    """ Return the distance between p1 and p2,
        which are points with coordinates
        (p1x, p1y) and (p2x, p2y)"""
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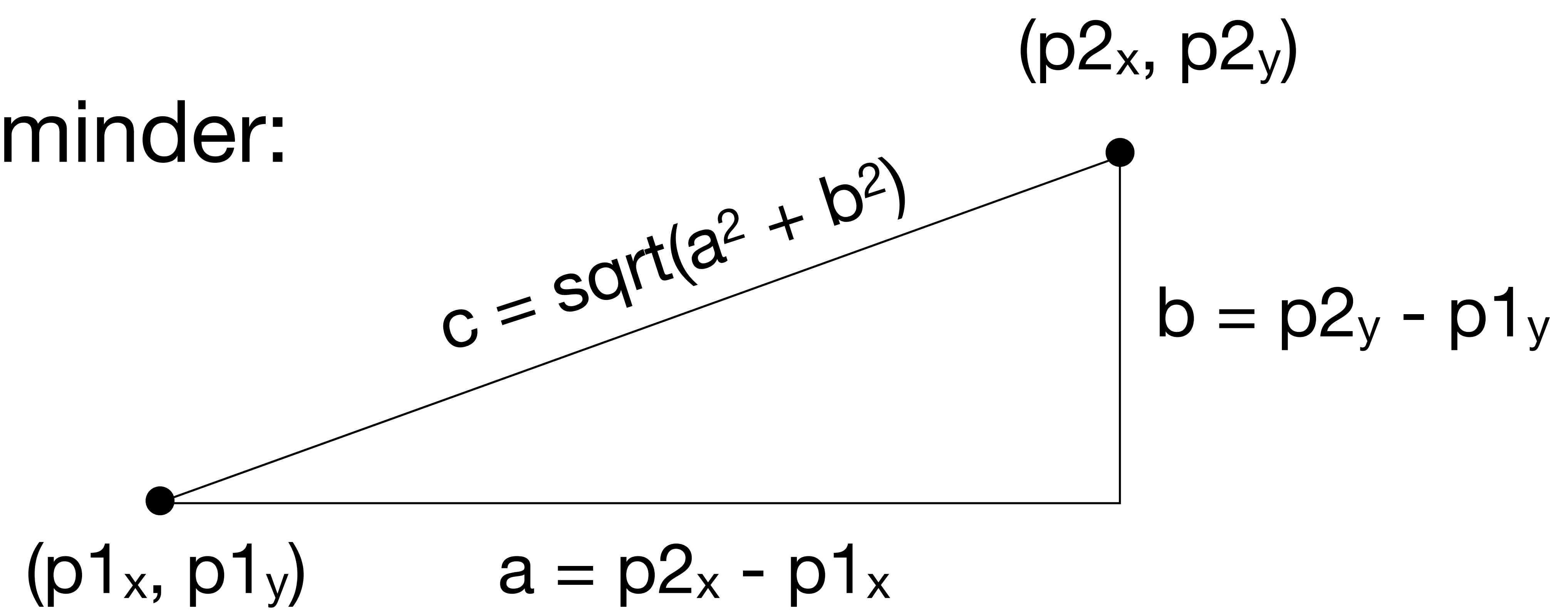

Demo: Distance Function

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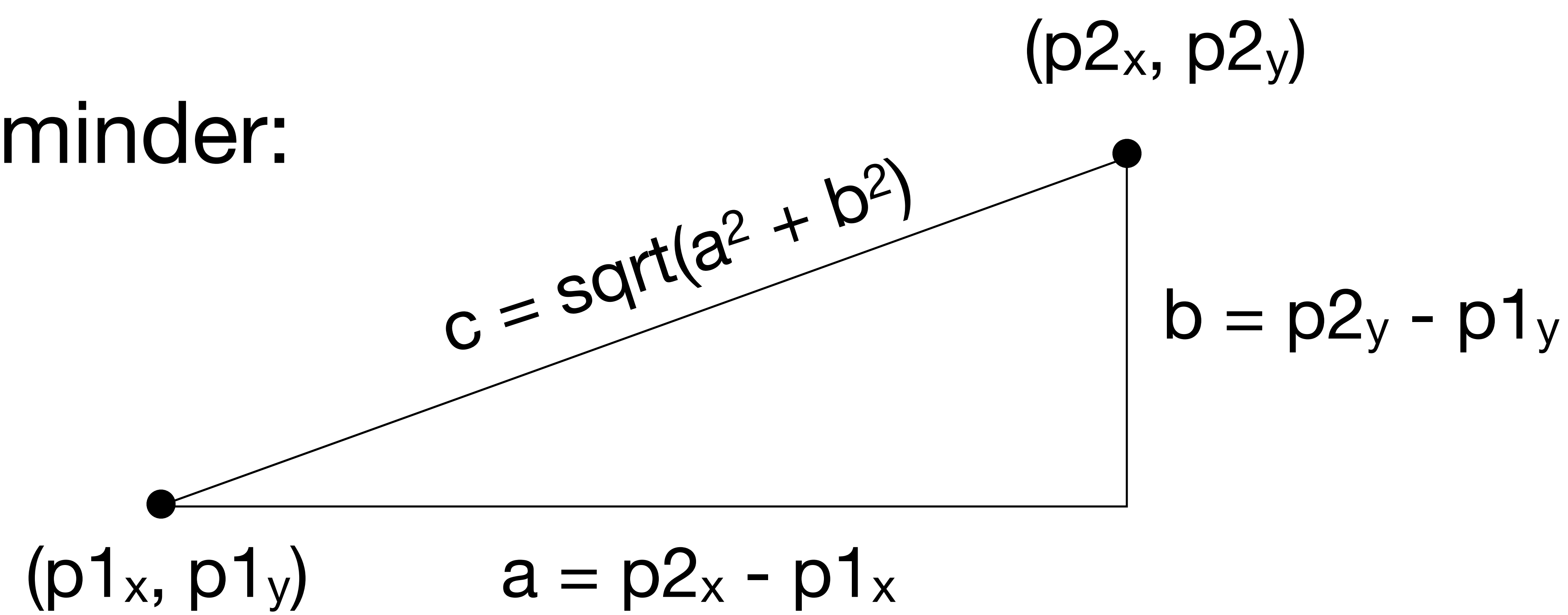

Reminder: Docstrings, Preconditions and Postconditions

Example. Suppose you wrote this function:

```
def split_bill(bill_amt, tip_pct, num_diners):
    """ Return the total owed by each diner for a
        restaurant bill of bill_amt, assuming a tip
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        evenly among num_diners people.

    """
    total = bill_amt + (bill_amt * tip_pct/100)
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Bad news: This is your fault.

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Function Composition

Here's a made-up equation:

```
final_result = (a + b)**2 - d // 12 + (a**2 - 0.5*a*c)  + alpha * (dx**2 + dy**2)
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It's pretty incomprehensible, even if you do know what a, b, d, c, alpha, dx, and dy mean.

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Here's a nicer way to write it:

```
x = (a + b)**2 - d // 12
y = (a**2 - 0.5*a*c)
z = alpha * (dx**2 + dy**2)

final_result = x + y + z
```

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What if x, y, and z weren't expressions, but more complicated computation requiring (for example) `for` loops to compute?

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```
def calc_x(a, b, d):
    # calculation of x

def calc_y(a, c):
    # calculation of y

def calc_z(alpha, dx, dy):
    # calculation of z

x = calc_x(a, b, d)
y = calc_y(a, c)
z = calc_z(alpha, dx, dy)
final_result = x + y + z
```

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What if this is just an intermediate result that goes into an even **larger** calculation?

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    # calculation of z

x = calc_x(a, b, d)
y = calc_y(a, c)
z = calc_z(alpha, dx, dy)
intermediate_result = x + y + z
```

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def calc_x(a, b, d):
    # calculation of x

def calc_y(a, c):
    # calculation of y

def calc_z(alpha, dx, dy):
    # calculation of z

def calc_gamma(a,b,c,d,alpha,dx,dy):
    x = calc_x(a, b, d)
    y = calc_y(a, c)
    z = calc_z(alpha, dx, dy)
    return x + y + z
```