THE UNIVERSITY OF CHICAGO

MASTERS IN COMPUTATIONAL SOCIAL SCIENCE
THE UNIVERSITY OF CHICAGO

MACS 30111

Functions

Misc

- Final exam! DATE TBD:
  - https://registrar.uchicago.edu/calendars/final-exams/
- **PA1** due 10/17
- **PA1 REFLECTION** due 10/20

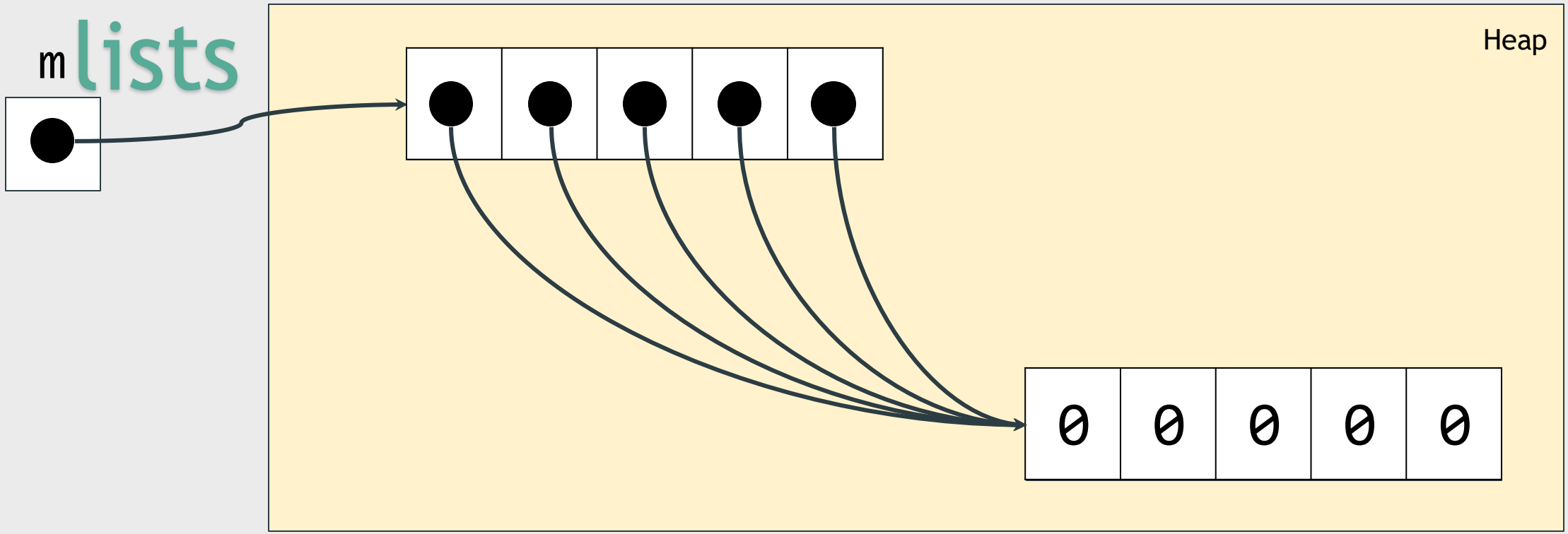
Agenda

- **Deep / shallow copies**
- Introduction to functions
- Function call control flow
- Return statements
- Parameters
- Scoping
- Abstraction

Lists of lists: where it gets weird

- Test out the following:
  - `m = [[0]*5]*5`
  - `m1 = [[0]*5 for i in range(5)]`
- Now, try: `m1[2][3] =1` vs `m[2][3] = 1`

Lists of lists



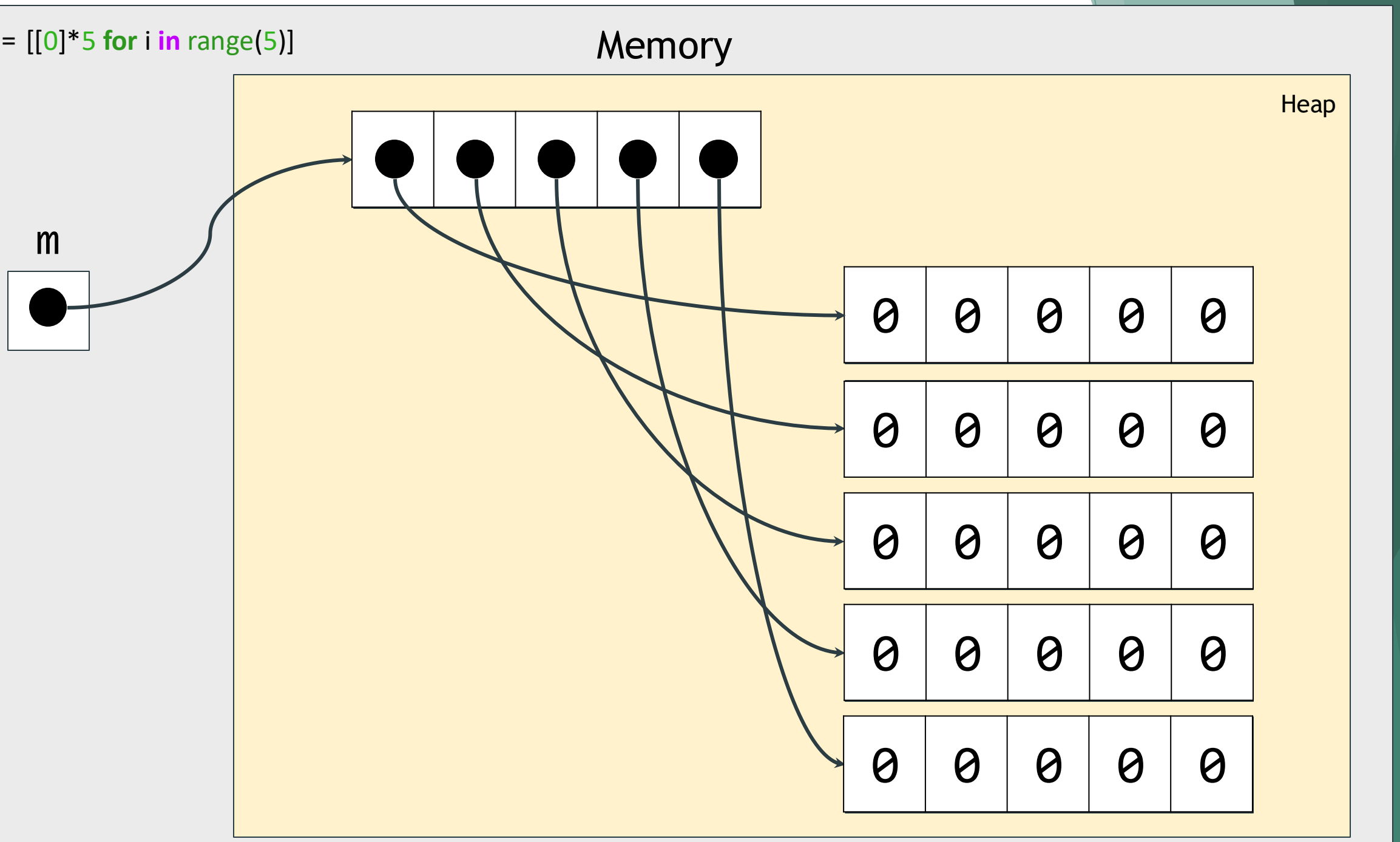

```
m = [[0]*5]*5
```

```
[[0, 0, 0, 0, 0],
 [0, 0, 0, 0, 0],
 [0, 0, 0, 0, 0],
 [0, 0, 0, 0, 0],
 [0, 0, 0, 0, 0]]
```

```
m[2][3] = 1
```

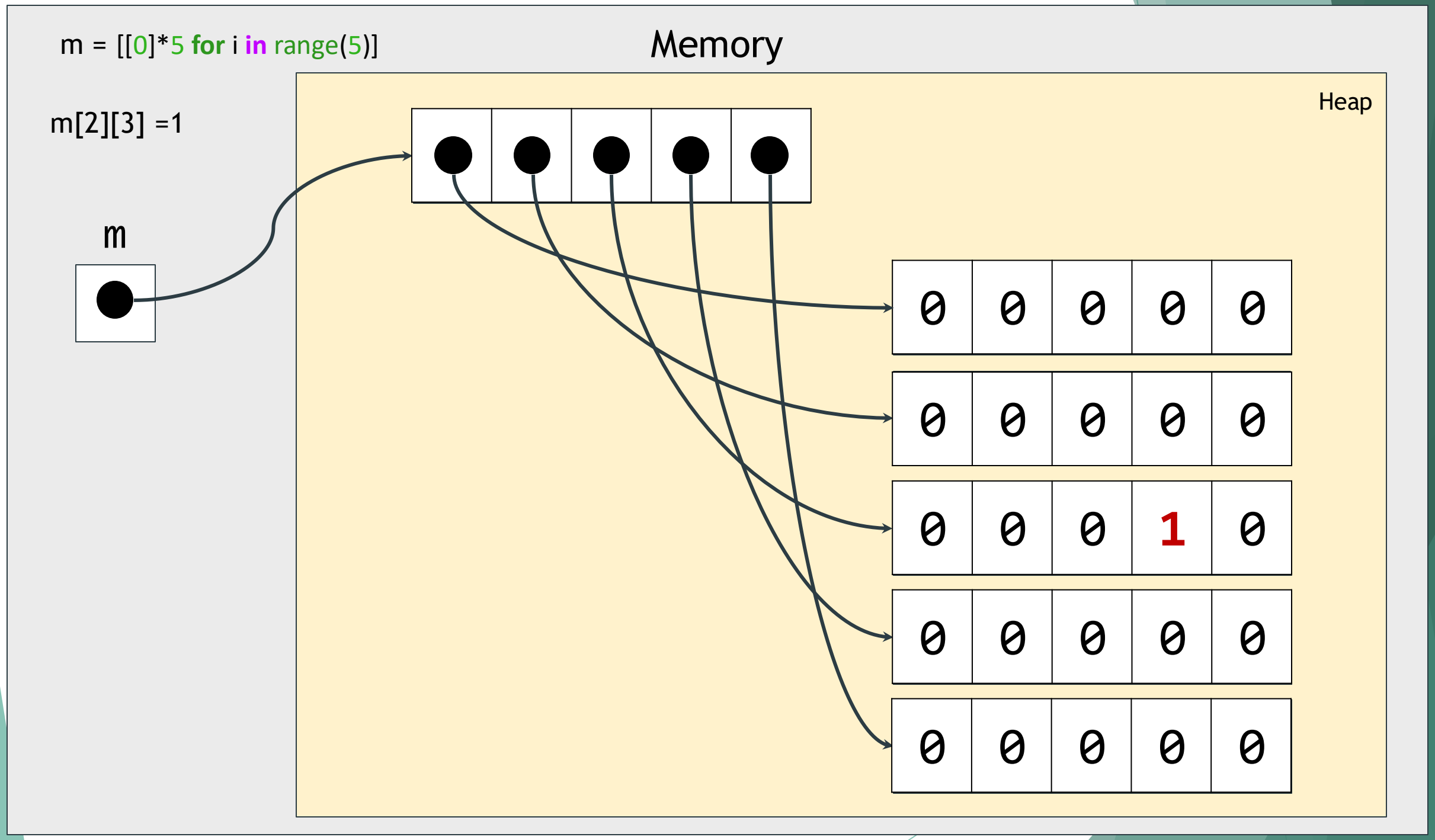
```
[[0, 0, 0, 1, 0],
 [0, 0, 0, 1, 0],
 [0, 0, 0, 1, 0],
 [0, 0, 0, 1, 0],
 [0, 0, 0, 1, 0]]
```

```
m = [[0]*5 for i in range(5)]
```



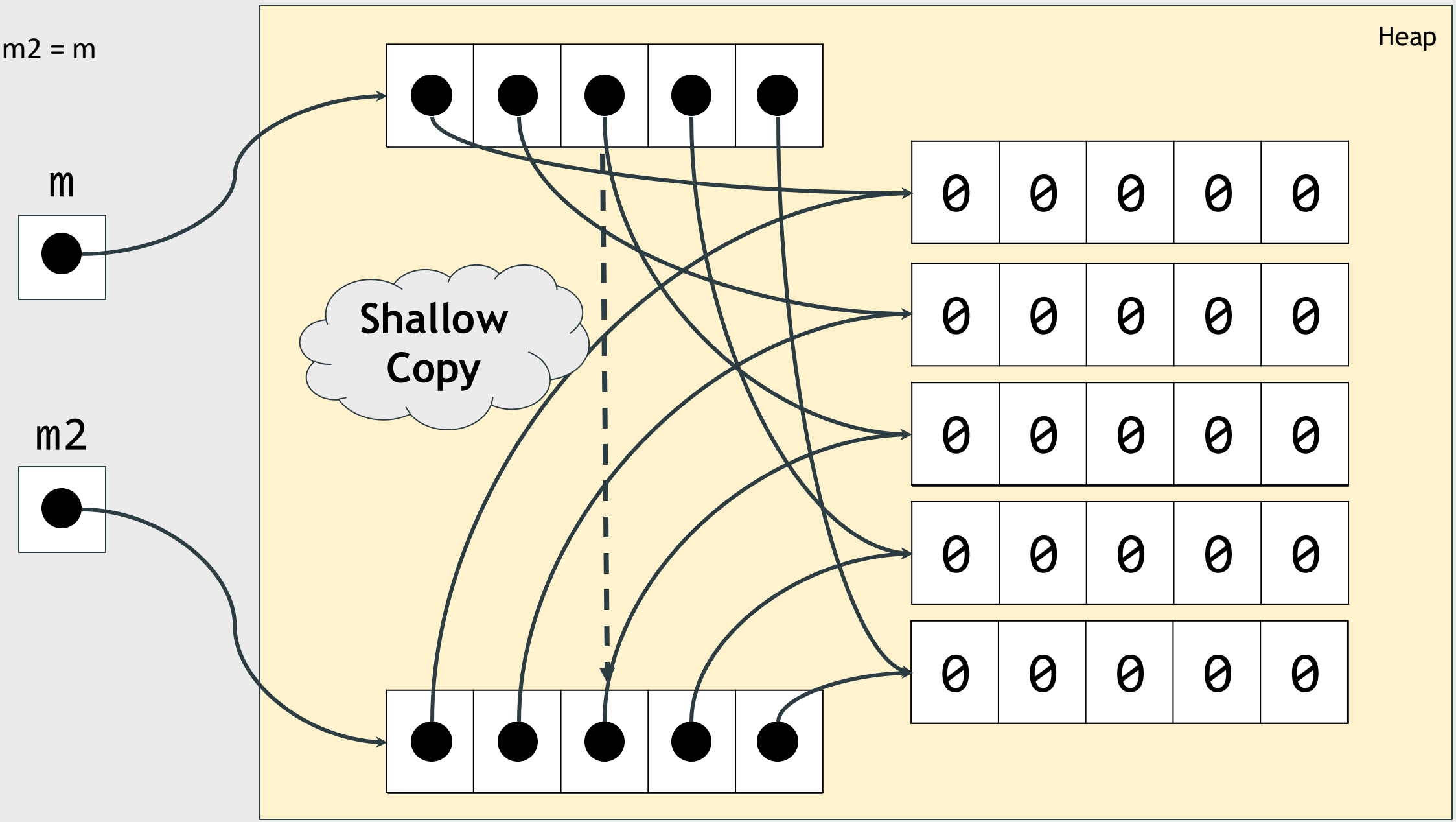
m = [[0]*5 **for** i **in** range(5)]

m[2][3] =1

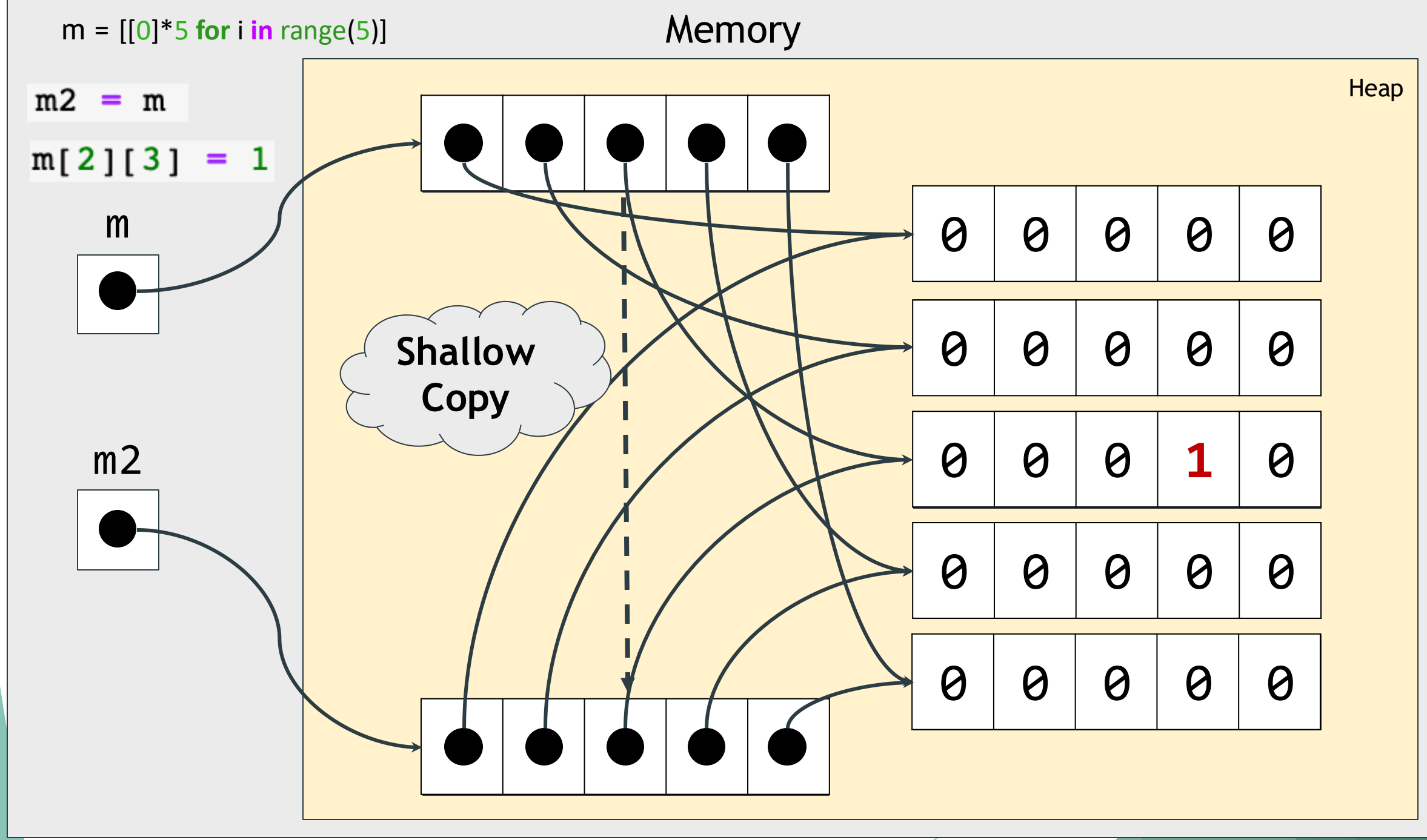


m= [[0]*5 **for** i **in** range(5)]

m2 = m



```
m = [[0]*5 for i in range(5)]
```



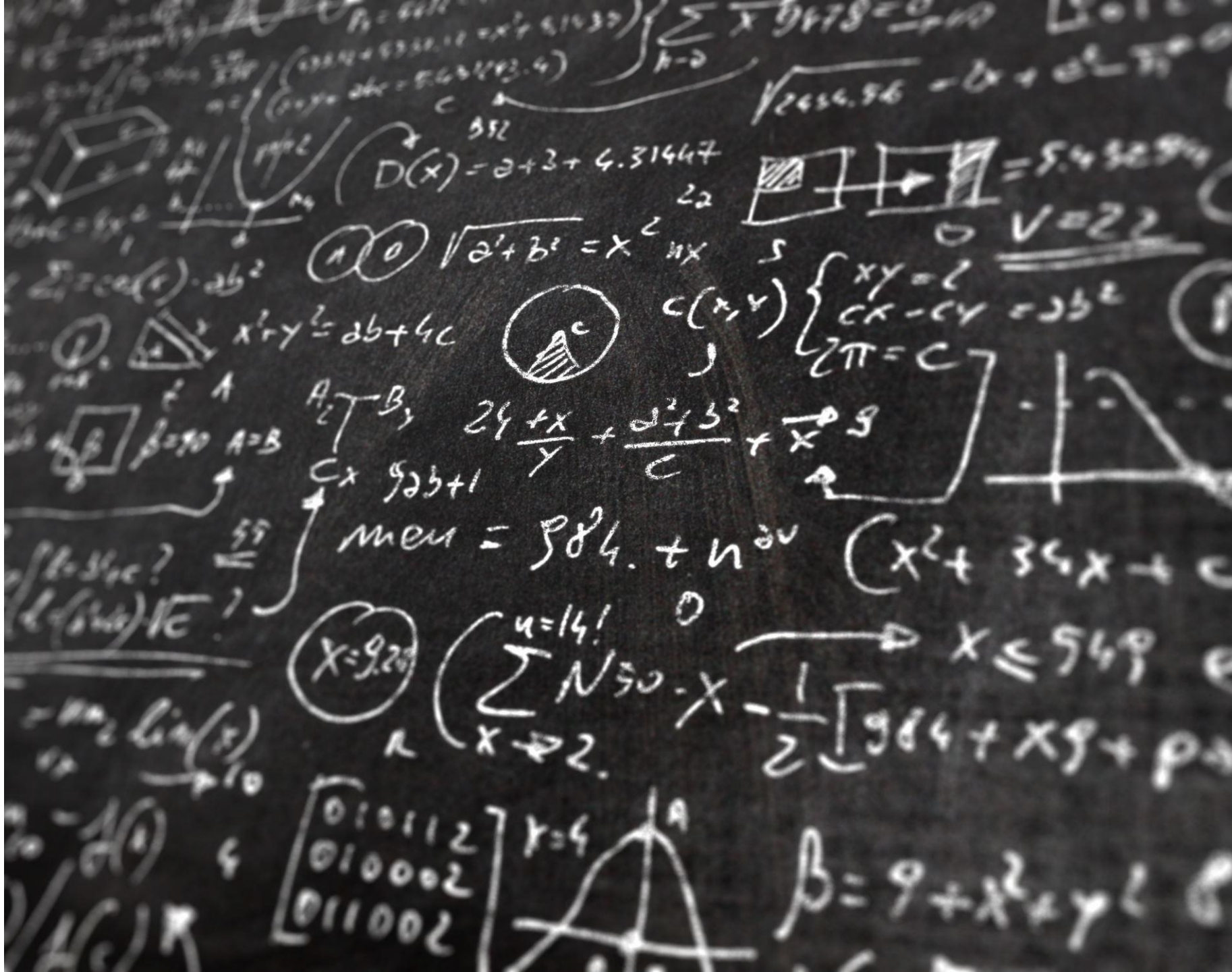
Memory: TL;DR

- SHALLOW VS DEEP
- Modify with new vs in-place

- Challenge q: can I use m[:] to make a deep copy of m?

- What about ‘copy’ module (imported)

Functions!



Example function

keyword name parameters

```
def multiply(a, b):
    '''
    Compute the product of two values.

    Inputs:
      a, b: the values to be multiplied.

    Returns: the product of the inputs
    '''

    n = a * b
    return n
```

Function header

docstring

body

Coding practice: 1.4.1

Function Call Control Flow

Calling a function alters the control flow of a program.

```
1  def multiply(a, b):
2      print("Start of multiply(a, b) function")
3      rv = a * b
4      print("End of multiply(a, b) function")
5      return rv
6
7  def main():
8      x = 5
9      y = 4
10     print("calling multiply(x, y)...")
11     z = multiply(x, y)
12     print("Returned from multiply(x, y)")
13     print("The value of z is", z)
```

return: specify the value to be returned to the caller and to transfer control back to the call site.

Testing: Zero, One, Many

- What does this mean?
- Why / how might it be meaningful?

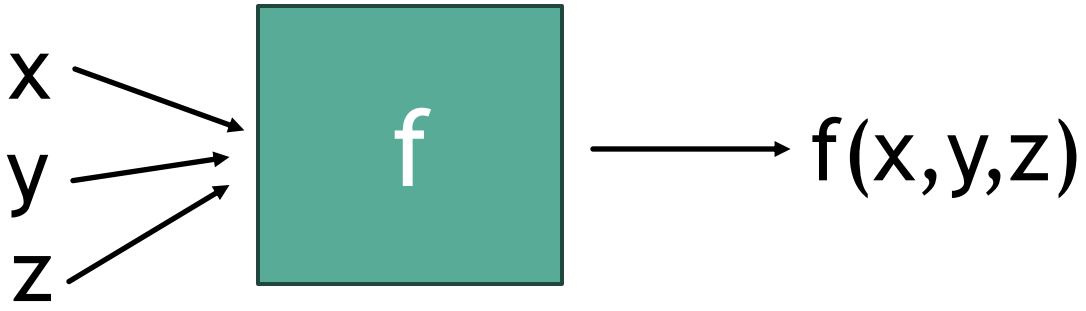
Topics:

- Shallow/deep copies

- Introduction to functions
- Function call control flow
- **Return statements**
- Parameters
- Scoping
- Abstraction

Mathematical Functions

Mathematical functions: take some values and produce a result.
Python functions: take some parameters as inputs and return some values as outputs.



Return Statements: multiple return statements

A return statement can appear **anywhere** in the function and can appear **multiple times.** Python computes the **return** value and leaves the function *immediately* upon encountering a **return** statement.

```
def absolute(x):
    '''
    Compute the absolute value of a number.

    Inputs:
        n (number): operand

    Returns (number): the magnitude of the input
    '''

    if x < 0:
        return -x
    else:
        return x
```

```
def is_prime(n):
    '''
    Determines whether the input is prime.

    Inputs:
      n (int): value to be checked

    Returns (boolean): True, if the input is prime and False
    otherwise
    '''

    if n == 1:
        return False

    for i in range(2, n):
        if n % i == 0:
            return False

    return True
```

Return Statements: multiple return statements

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```
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    '''

    if n == 1:
        return False

    for i in range(2, n):
        if n % i == 0:
            return False

    return True
```

Return Statements: return multiple values

A function can return **multiple values** using a tuple.

```
def bounds(lst):
    min_val = min(lst)
    max_val = max(lst)
    return min_val, max_val
```

Parameters

Call-by-value

```
def multiply(a,b):
'''
Compute the product of two values.
Inputs: a, b: the values to be multiplied.
Returns: the product of the inputs.
'''

n = a * b
return n
```

Different ways to call the function:

```
multiply(3, 4)

2 + multiply(3, 4)
print("2 x 3 =", multiply (2,3))

x = 3
y = 5

multiply(x,y)

multiply(x-1, y+1)
multiply(4, multiply (3,2))
```

Parameters with Default Values

- specify a default value for parameters
- come at the end
- can be omitted or overwritten

```
def multiply(a, b = 10):
'''
Compute the product of two values.
Inputs: a, b: the values to be multiplied.
Returns: the product of the inputs.
'''

n = a * b
return n
```

```
multiply(2,3)
multiply(2)
multiply(a=2, b=5)
```

Coding practice: 1.4.6.2

Positional and Keyword Parameters

- Map to specific parameters depending on the position in the list of arguments.
- Specify the exact parameter using keyword arguments, position doesn't matter.
- Combining positional and keyword arguments, positional arguments must come first

```
def multiply(a,b):
'''
Compute the product of two values.
Inputs: a, b: the values to be multiplied.
Returns: the product of the inputs.
'''

n = a * b
return n
```

```
multiply(2,3)
multiply(2, b = 3)
multiply(a=2, b=5)
```

Note: be careful if you only specify one variable

Coding practice: 1.4.6.3

Topics:

- Introduction to functions
- Function call control flow
- Return statements
- Parameters
- **Scoping**
- Abstraction

Scoping

- Variables are only valid in a specific part of the code
- **Local** variables: variables defined inside a function, only valid within the function
- **Global** variables: variables defined outside of a function.
- When a global variable and a local variable have the same name, the local variable shadows the global variable.

```
c = 5

def add_c(x, c):
'''
Add x and c
'''
return x + c

add_c(3,2)
```

```
def update_c(new_c):
'''
Update value of c
'''

global c
c = new_c
```

Coding practice: 1.4.5 / 1.4.7

Functions as an abstraction mechanism

- **Organize** work into separate tasks
  - Every function should have a clear purpose.
- **Reuse** code (and avoid repeated code)
  - Whenever you find yourself cutting-and-pasting a block of code, ask yourself whether it would be better to create a function instead of repeating the block of code.
- **Test** the solution for a task in (relative) isolation

Coding practice: 1.4.2

Functions: return vs print

- Print: displays in console
- Returns: what 'comes out' from the function

```
def multiply(a, b):
    ''' Print the product of two values. Inputs: a, b:
the  values to be multiplied. Returns: None '''

    n = a * b
    print(n)

rv = multiply(5, 2)
print("The return value is:", rv)
```

```
The return value is: None
```

```
def multiply(a, b):
    ''' Print the product of two values. Inputs: a, b:
the  values to be multiplied. Returns: None '''

    n = a * b
    return n

rv = multiply(5, 2)
print("The return value is:", rv)
```

```
The return value is: 10
```

Note: what happens when you call rv = multiply(5,2)?

Functions: how to think about them deeply

- What are you trying to do?
- How can you break it down?
- Where are the complex parts of your code?
- Where do you think you might run into issues?

Simulate a game with dice

- Going to Boston
  - https://www.youtube.com/watch?v=MbBwiAUsSI8

- Rules:
  - roll all three dice and set aside the largest one
  - roll the remaining two dice and set aside the largest one
  - roll the remaining die
  - sum of the above values is the score for the round
  - The players keep playing until one reaches 500 and wins.

Coding practice: 1.4.4

Exercise: Steps

- In pairs, work through exercise 1.4.4:
  - Create a file that has multiple functions in it
  - **SKETCH INDEPENDENTLY FIRST** but then **YES USE THE TEXT!!*
  - Be sure all is clean and clear
- Discuss **two innovations** / extensions / ‘twists’ on the game:
  - One that is difficult for the code as written:
    - Why is this difficult? Is there a way you could have written your code differently to address this?
  - One that will be easy to adapt:
    - Why is this easy? How does the structure of the code lend itself to this?

Work it out: What will you use

- Sketch your structure:
  - Big pieces first (main method)
  - Small pieces next (helper functions)
  - Details last (doc strings, etc)

Code ideas (1.4.4)

```
def play_round():
''' Play a round of the game Going to Boston using three dice. Inputs: none Return (int): score earned '''
NUM_SIDES = 6 score = 0

# roll 3 dice, choose largest
die1 = random.randint(1, NUM_SIDES)
die2 = random.randint(1, NUM_SIDES)
die3 = random.randint(1, NUM_SIDES)
largest = max(die1, max(die1, die2))
score += largest

# roll 2 dice, choose largest
die1 = random.randint(1, NUM_SIDES)
die2 = random.randint(1, NUM_SIDES)
largest = max(die1, die2) score += largest

# roll 1 die, choose largest
largest = random.randint(1, NUM_SIDES)
score += largest

return score
```

Code ideas (1.4.4)

```
def play_round():
''' Play a round of the game Going to Boston using three dice. Inputs: none Return (int): score earned '''
NUM_SIDES = 6 score = 0

# roll 3 dice, choose largest
die1 = random.randint(1, NUM_SIDES)
die2 = random.randint(1, NUM_SIDES)
die3 = random.randint(1, NUM_SIDES)
largest = max(die1, max(die1, die2))
score += largest

# roll 2 dice, choose largest
die1 = random.randint(1, NUM_SIDES)
die2 = random.randint(1, NUM_SIDES)
largest = max(die1, die2) score += largest

# roll 1 die, choose largest
largest = random.randint(1, NUM_SIDES)
score += largest

return score
```

We're calling random.randint and taking the largest – maybe we want to specify a number of rolls and a max fn?

```
def get_largest_roll(num_dice)
def play_round()
```

TESTING (general steps)

- DOWNLOAD ALL FILES TO GOOD PLACE
- In terminal (either VS code or straight terminal), navigate to your folder where the files are.
- Call ipython
- Load autoreload

TESTING

- In terminal (either VS code or straight terminal), navigate to your folder where the files are.
- Call ipython
- Autoreload:

```
In [1]: %load_ext autoreload


In [2]: %autoreload 2
```

- Import the 'base name' of your file (e.g. for boston.py, **import boston**)
- Call the function using **name.function()**

```
In [3]: import boston


In [4]: boston.play_round_generalized(3)
Out[4]: 16
```

Innovations?

- What changes did you make?

Test files

- BE IN YOUR CONDA ENVIRONMENT (e.g. 111)
- conda install pytest
- py.test <options> <method> test_assign.py
  - Options: https://docs.pytest.org/en/6.2.x/usage.html

Sucessful code

```
cachedir: .pytest_cache
rootdir: /Users/jeanclipperton/Library/CloudStorage/Box-Box/Teaching/30111/macs30111/class_examples/SE2_sample_example
configfile: pytest.ini
plugins: django-4.9.0
collected 40 items

test_se2.py::test_peep_1 PASSED                                   [  2%]
test_se2.py::test_peep_2 PASSED                                   [  5%]
test_se2.py::test_peep_3 PASSED                                   [  7%]
test_se2.py::test_peep_4 PASSED                                   [ 10%]
test_se2.py::test_peep_5 PASSED                                   [ 12%]
test_se2.py::test_peep_6 PASSED                                   [ 15%]
test_se2.py::test_has_more_1 PASSED                               [ 17%]
test_se2.py::test_has_more_2 PASSED                               [ 20%]
test_se2.py::test_has_more_3 PASSED                               [ 22%]
test_se2.py::test_has_more_4 PASSED                               [ 25%]
test_se2.py::test_has_more_5 PASSED                               [ 27%]
test_se2.py::test_has_more_6 PASSED                               [ 30%]
test_se2.py::test_has_more_7 PASSED                               [ 32%]
test_se2.py::test_has_more_8 PASSED                               [ 35%]
test_se2.py::test_make_star_strings_1 PASSED                      [ 37%]
test_se2.py::test_make_star_strings_2 PASSED                      [ 40%]
test_se2.py::test_make_star_strings_3 PASSED                      [ 42%]
test_se2.py::test_make_star_strings_4 PASSED                      [ 45%]
test_se2.py::test_make_star_strings_5 PASSED                      [ 47%]
test_se2.py::test_make_star_strings_6 PASSED                      [ 50%]
test_se2.py::test_replace_1 PASSED                                [ 52%]
test_se2.py::test_replace_2 PASSED                                [ 55%]
test_se2.py::test_replace_3 PASSED                                [ 57%]
test_se2.py::test_replace_4 PASSED                                [ 60%]
test_se2.py::test_replace_5 PASSED                                [ 62%]
test_se2.py::test_replace_6 PASSED                                [ 65%]
test_se2.py::test_replace_7 PASSED                                [ 67%]
test_se2.py::test_replace_8 PASSED                                [ 70%]
test_se2.py::test_rows_and_columns_contain_1 PASSED               [ 72%]
test_se2.py::test_rows_and_columns_contain_2 PASSED               [ 75%]
test_se2.py::test_rows_and_columns_contain_3 PASSED               [ 77%]
test_se2.py::test_rows_and_columns_contain_4 PASSED               [ 80%]
test_se2.py::test_rows_and_columns_contain_5 PASSED               [ 82%]
test_se2.py::test_rows_and_columns_contain_6 PASSED               [ 85%]
test_se2.py::test_rows_and_columns_contain_7 PASSED               [ 87%]
test_se2.py::test_rows_and_columns_contain_8 PASSED               [ 90%]
test_se2.py::test_rows_and_columns_contain_9 PASSED               [ 92%]
test_se2.py::test_rows_and_columns_contain_10 PASSED              [ 95%]
test_se2.py::test_rows_and_columns_contain_11 PASSED              [ 97%]
test_se2.py::test_rows_and_columns_contain_12 PASSED              [100%]

=========================== 40 passed in 0.05s ===========================
(111) jeanclipperton@MARSS-35004L SE2_sample_example %
```

Recap

- Functions **underpin a LOT** of what we'll be doing
- **Function call control flow**: can move around in the file (potentially never call something!!)
- **Return statements**: can put where needed, generally good to have
- **Parameters**: what values the function takes
- **Scoping**: local vs global variables
- **Anatomy:** function and parameters, doc string, body (aka code), return statement