THE UNIVERSITY OF CHICAGO

MASTERS IN COMPUTATIONAL SOCIAL SCIENCE
THE UNIVERSITY OF CHICAGO

MACS 30111

List, Tuples, and Strings

Misc: Assignment deadlines

- SE1 due tomorrow
- SE2 due FRIDAY
- SE2 REFLECTION due MONDAY
  - Grading about whether you critically engaged with where you are / the assignment
  - NO: ‘it went ok’
  - Yes: it was OK but I struggled with part 3 because *reason*
- PA1 due 10/13
  - START NOW!!!! Work on it in chunks!!
- PA1 REFLECTION due 10/16

K WL

Know (learned from readings)	Want to know (questions you have)	Learned (leave blank for now)

Topics:

- Pythonic
- Introduction
- List creation and basic usage
- List iteration
- Adding, removing elements from a list
- List slicing
- Lists of lists
- Tuples
- Strings
- List Comprehensions
- Lists in Memory (Probably Thursday)

Pythonic: what does it mean?

- Clean
- Beautiful
- Correct

- Alternative: *brute force*

Lists, Tuples, and Strings

Basic data types: integers, floats, strings, and booleans.

With these data types, a variable only contains a single value.

```
In [1]: n = 5

In [2]: n
Out[2]: 5
```

Lists, Tuples, and Strings

Construct more complex data structures from basic data types.

```
In [1]: for n in [1, 4, 8, 9, 11]:
   ...:     print(n)
   ...:
1
4
8
9
11
```

numbers = [1, 4, 8, 9, 11]

Variable *numbers* contains a list of five integers.

Topics:

- Introduction
- **List creation and basic usage**
- List iteration
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Creating Lists

```
lang = ["C", "C++", "Python", "Java"]
```

A pair of square brackets
Values separated by comma

- Creating a literal list
- Creating an empty list
- Creation by concatenation
- Creation by multiplication

Coding practice: 2.1.1

Creating Lists

Coding practice: 2.1.1

- How are the following different, if at all?
  - lst = [0, 1] * 10
  - lst = [0] * 10 + [1] * 10
  - lst = [0, 1, 0, 1, 0, 1, 0, 1, 0, 1]

Basic Usage: code used

```
lang = ["C", "C++", "Python", "Java"]
```

- List length
- Accessing elements in a list
- Assigning a value to an element of the list
- Negative indices

Coding practice: 2.1.2

Basic Usage: code used

```
lang = ["C", "C++", "Python", "Java"]
```

- List length: `len(lang)`
- Accessing elements in a list: `lang[0]`
- Assigning a value to an element of the list: `lang[0] = “perl”`
- Negative indices `lang[-1]`

Coding practice: 2.1.2

Code snippet

```
lang = ['C', 'C++', 'Python 3', 'Java’]
len(lang)
lang[2]
lang[5]
lang[0] =“perl”
lang[-1]
```

Throws an error! But why?

Quiz

Which of the following is NOT a valid way to create a list?

- lst = []
- lst = [1, 2, 3, 4]
- lst = 1 + 2 + 3 + 4
- lst = [0, 1] * 10

True/False: In Python, all the elements of a list must be of the same type?

Topics:

- Introduction
- List creation and basic usage
- **List iteration**
- Adding, removing elements from a list
- List slicing
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List Iteration

iterate through the list and perform an action for each element in the list

```
In [1]: for n in [1, 4, 8, 9, 11]:
   ...:     print(n)
   ...:
1
4
8
9
11
```

enumerate()

Iterate the list over the indices

unpythonic

```
for i in range(len(prices)):
    print("Item", i, "costs", prices[i], "dollars")
```

Python provides a way to iterate the list over the indices and values directly with the built-in **`enumerate`** function:

```
for i, p in enumerate(prices):
    print("Item", i, "costs", p, "dollars")
```

unpack as (index, value) tuples

Coding practice: 2.1.3

Quiz

How do I iterate over the values in a list?

- Using a “foreach” loop
- Using a “for” loop
- Using the built-in iterate() function

Which of the following loops is unpythonic?

- for i in range(len(lst)):
- for x in lst:
- for i, x in enumerate(lst):

Applied practice

- Create a list counting by three starting at 0 and going to 60 (inclusive)
  - `nums = list(range(0,61, 3))`

Topics:

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Adding elements to a list

- *append()*
- *extend()*
- The + operator
- *insert()*
- In-place vs returning a new list (*id()*)

Coding practice: 2.1.4

Removing elements from a list

- *pop()* (remove by position)
- *remove()* (remove by value)
- Built-in operator *del*

Coding practice: 2.1.4

Quiz

Does append() return a new list?

- No, it modifies the list in-place
- Yes, it leaves the list intact, and returns a new list with the appended value.

Which of the following functions will remove an element from a list?

- extract
- pop
- excise

Topics:

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List Comprehension

List comprehensions are more compact ways to generate a list

<list name> = **[** <transformation expression> **for** <variable name> **in** <list expression> **]**

Note: for this, you can add conditionals but the formatting gets a little weird:

<list name> = **[** <transformation expression> **for** <variable name> **in** <list expression> if <condition>**]**

BUT

<list name> = **[** <transformation expression> if <condition> else <transformation expression> **for** <variable name> **in** <list expression>**]**

List Comprehension

Given a list of integers, create a *new* list with those same numbers multiplied by 2.

```
lst = [1, 2, 3, 4]
new_lst = []
for x in lst:
    new_val = x*2
    new_lst.append(new_val)
```

A compact syntax using list comprehensions:

```
new_lst = [x*2 for x in lst]
```

Coding practice: 2.1.5

List Comprehension

Given a list of integers, create a *new* list with those same numbers multiplied by 2.

```
lst = [1, 2, 3, 4]
new_lst = []

for x in lst:
    new_val = x*2
    new_lst.append(new_val)
```

```
<list name> = [ <transformation expression> for <variable name>
                                    in <list expression> ]
```

```
new_lst = [x*2 for x in lst]
```

New List Variable Existing List Expression

List Comprehension

Create a new list from an existing list, but filtering elements based on some condition. For example:

```
lst = [1, 2, 3, 4]

new_lst = []
for x in lst:
    if x % 2 == 0:
        new_lst.append(x)
```

We can use a **list comprehension** for this too:

```
new_lst = [x for x in lst if x % 2 == 0]
```

```
[ <transformation expression> for <variable name> in <list expression> if <boolean expression> ]
```

Applied practice

- Create a list counting by three starting at 0 and going to 60 (inclusive)
- Create a new list using this original list: square even numbers and make odd numbers negative
  - One partner does it the ‘long’ way and one try it with a list comprehension

Topics:

- Introduction
- List creation and basic usage
- List iteration
- Adding, removing elements from a list
- **List slicing**
- Lists of lists
- Tuples
- Strings
- List Comprehensions
- Lists in Memory

List slicing

Use the brackets operator to access individual elements of a list:

```
In [1]: lang = ['C', 'C++', 'Python', 'Java']

In [2]: lang[2]
Out[2]: 'Python'
```

List slicing

Specify a range of positions: specifying two indexes separated by a colon:

```
In [1]: lang = ['C', 'C++', 'Python', 'Java']

In [2]: lang[1:3]
Out[2]: ['C++', 'Python 3']
```

- A slice is a copy that doesn't refer back to the original list
- Omitting slice operands
- [:] as a way to copy lists
- Step through the list

Coding practice: 2.1.2.1

Other operations

- *[::] to pull out based on index patterns*

```
In [49]: new_list[::2]
Out[49]: [0, 36, 144, 324, 576, 900, 1296,
1764, 2304, 2916, 3600]
```

```
In [50]: new_list[1::2]
Out[50]: [-3, -9, -15, -21, -27, -33, -39,
-45, -51, -57]
```

Coding practice: 2.1.6

K WL

Know (learned from readings)	Want to know (questions you have)	Learned (fill in now)

Topics:

- Introduction
- List creation and basic usage
- List iteration
- Adding, removing elements from a list
- List Comprehensions
- **List Operations**
- **Lists of lists**
- **Tuples**
- **Strings**
- **Lists in Memory**

Misc

- Workshop: Need to end by 10:45!!!
- SE1 grades up (sorry for multiple emails)
- Ed: EXCELLENT QUESTIONS!!
- Check in:
  - How comfortable do you feel with the following:
    - pytest
    - Calling your code in an interpreter
    - Testing out code snippets
    - How often do you **actually** do testing, etc (be honest!)

Quiz

Which of the following specifies a slice of a list?

- lst[4-7]
- lst[4..7]
- lst[4:7]

If I create a slice of a list, and then modify a value in the slice...

- The contents of the original list are unaffected
- The contents of the original list are changed as well

Other operations

- *min()*
- *max()*
- *sum()*
- *count()*
- *in*
- *reverse()*
- *sort()* VS *sorted()*

Coding practice: 2.1.6

Operator comparison

- Start with a list: 0-100 by 5s.
- Provide the following:
  - Write two ways to find out if 15 is in the list
  - Write two ways to remove the number 10
  - Write two ways to reverse the list

Topics:

- Introduction
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- List Comprehensions
- List slicing
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Lists of lists

So far, we have seen lists containing simple values:

```
lst = [1, 2, 3, 4]
```

However, lists can also **contain other lists**:

```
m = [ [1,2,3,4], [5,6,7,8], [9,10,11,12] ]
```

This is a common way of representing matrix-like data.

1	2	3	4
5	6	7	8
9	10	11	12

Lists of lists

1	2	3	4
5	6	7	8
9	10	11	12

- access individual elements: use square brackets twice
- assign individual elements
- list-of-lists-of-lists

Coding practice: 2.1.10

Quiz

True/False: A list can contain other lists, but I need to specify the sub-lists with curly braces (e.g., m = [{1,2,3}, {4,5,6}])

If I want to treat a list of lists like a matrix…

- It is up to me to ensure it is a valid matrix. Python won't enforce matrix semantics.
- Python will enforce matrix semantics, as long as the variable name starts with the letter "m"
- Python will enforce matrix semantics automatically if all the lists are of the same length, and if they all contain a numeric type (integer or float)

Matrix party

- Import random and set your seed to 4: random.seed(4)
- Create a matrix: 3 x 3 matrix full of random odd integers that range from 0 to 11 (inclusive)
- What is the middle row?
- Check that the second element of the middle row is >5
- Replace **in place** all 5s with 7s

Lists: HELP!

- Help me determine what is wrong here:

```
m = [[3, 3, 7], [7, 11, 11], [7, 1, 9]]

n = []

for i in m:
    print(m)
    if m[i] == 3:
    n[i] = 6
```

Topics:

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Tuple

A tuple is very similar to a list, except it uses ***parentheses*** and is ***immutable***. Once I create a tuple, I cannot change the values contained in the tuple.

```
tpl = (1, 2, 3, 4)
```

When iterating over a list of tuples, we can have a for loop automatically ***unpack*** the tuples

```
employees = [ ("Sam", "CEO"), ("Alex", "CTO"), ("Pat", "VP") ]

for name, position in employees:
    print(name, "is the", position)
```

Coding practice: 2.1.12

Tuple

- Can you tell by looking at something if it’s a tuple?
- Why / when might we use them over lists?

Topics:

- Introduction
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Strings

```
msg = "Hello, world!"
```

- Store text values
- A list of individual characters, most list operations are also available on strings.
- Methods we can invoke: *in, find, lower, upper, capitalize, replace, split, join*
- Python mechanisms for formatting strings

Coding practice: 2.1.13

Strings: checking it out

- You can do a lot of the same operations on a string that you can with list (not totally, but a lot of similar ones!)

- Start with a string and try the following:
  - upper
  - lower
  - +=
  - print(“{} is my favorite”.format(var))

Strings: intermediate

- Advice on what to do?

s = “WhEn I wAlK in tHE roOm I cAn stILl mAke the wHOle PLace SHIMMER. ”

Strings: advanced (good OH question!)

- **Consider the following:**

s= [[”Baby love, I think I've been a little too. Kind”], [“Didn't notice you walkin' all over my peace of mind”], [“In the shoes I gave you as a present”]]

- How can we clean this up?

Quiz

True/False: Tuples and lists are interchangeable types and behave exactly the same way. The only difference is we use parentheses instead of brackets.

Quiz

True/False: After I create a string, I can use the brackets operator to change individual characters (e.g., s[1] = “X”)

Which of the following is a valid example of string formatting in Python? (assuming that x contains an integer value)

- “The number is $x”
- “The number is <int>”.format(x)
- “The number is {}”.format(x)

Topics:

- Introduction
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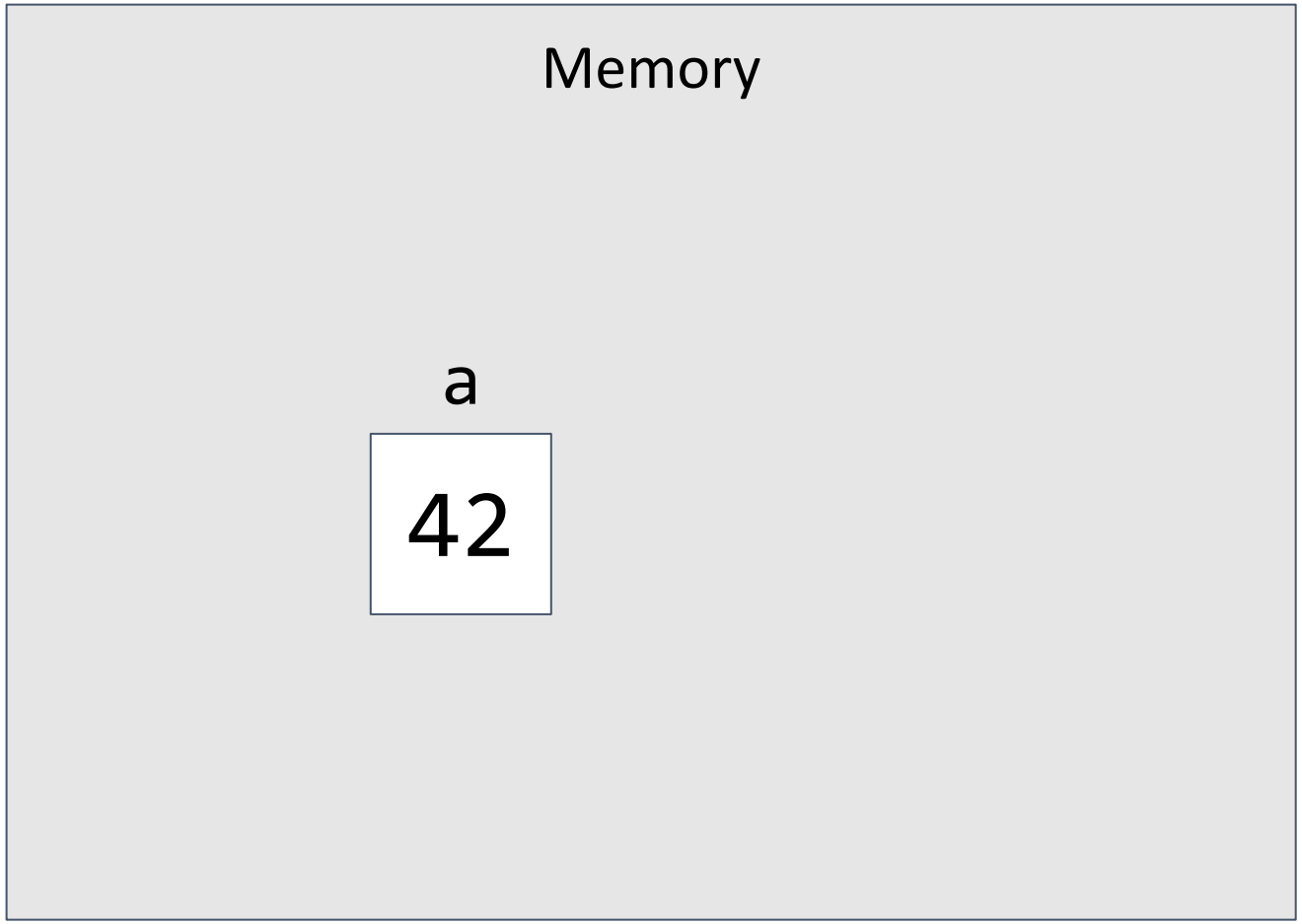
- List Comprehensions
- **Lists in Memory**

MEMORY!

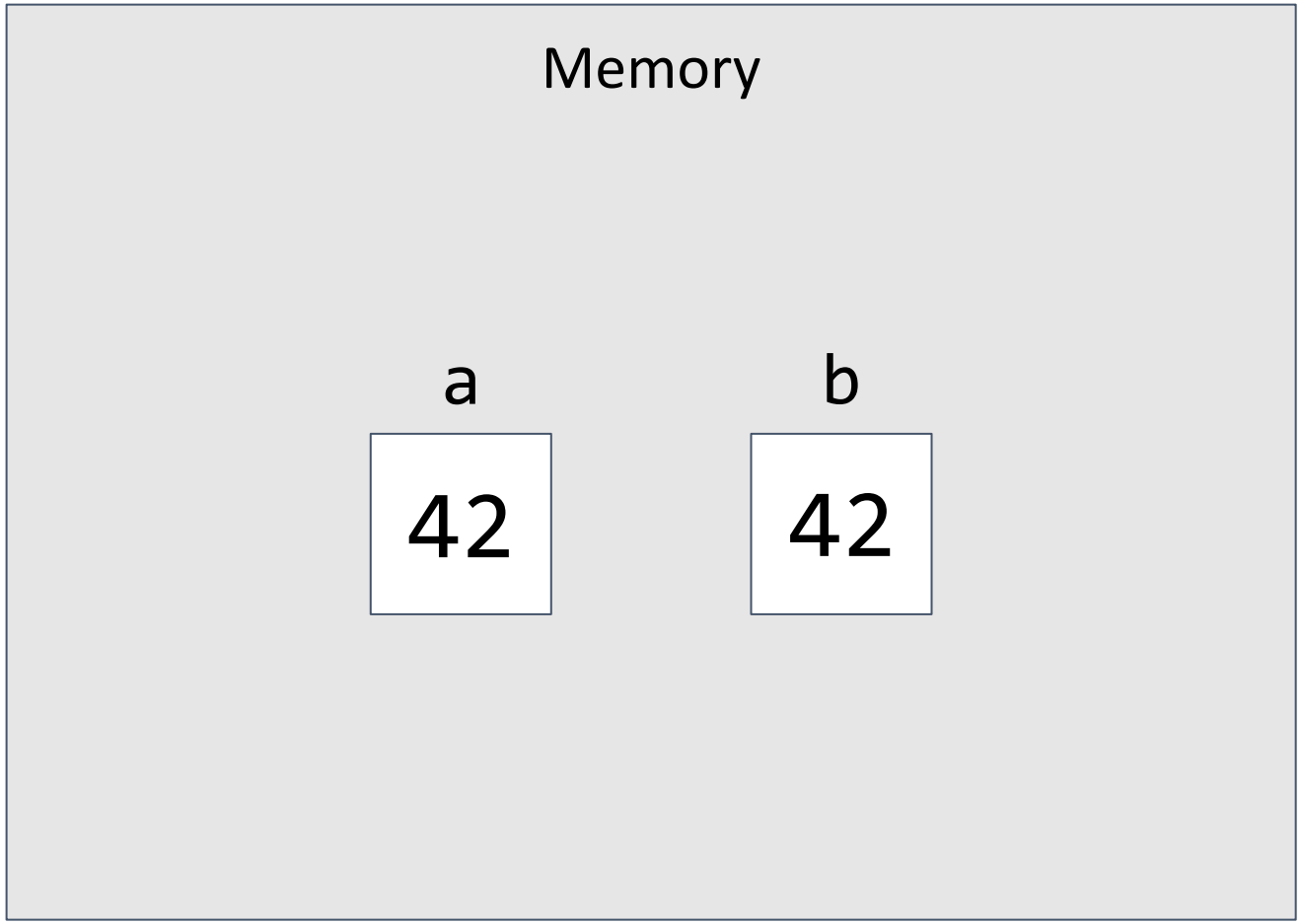
- Think about how things are stored – are they made somewhat easily accessible or are they harder to access?

Variables Revisited



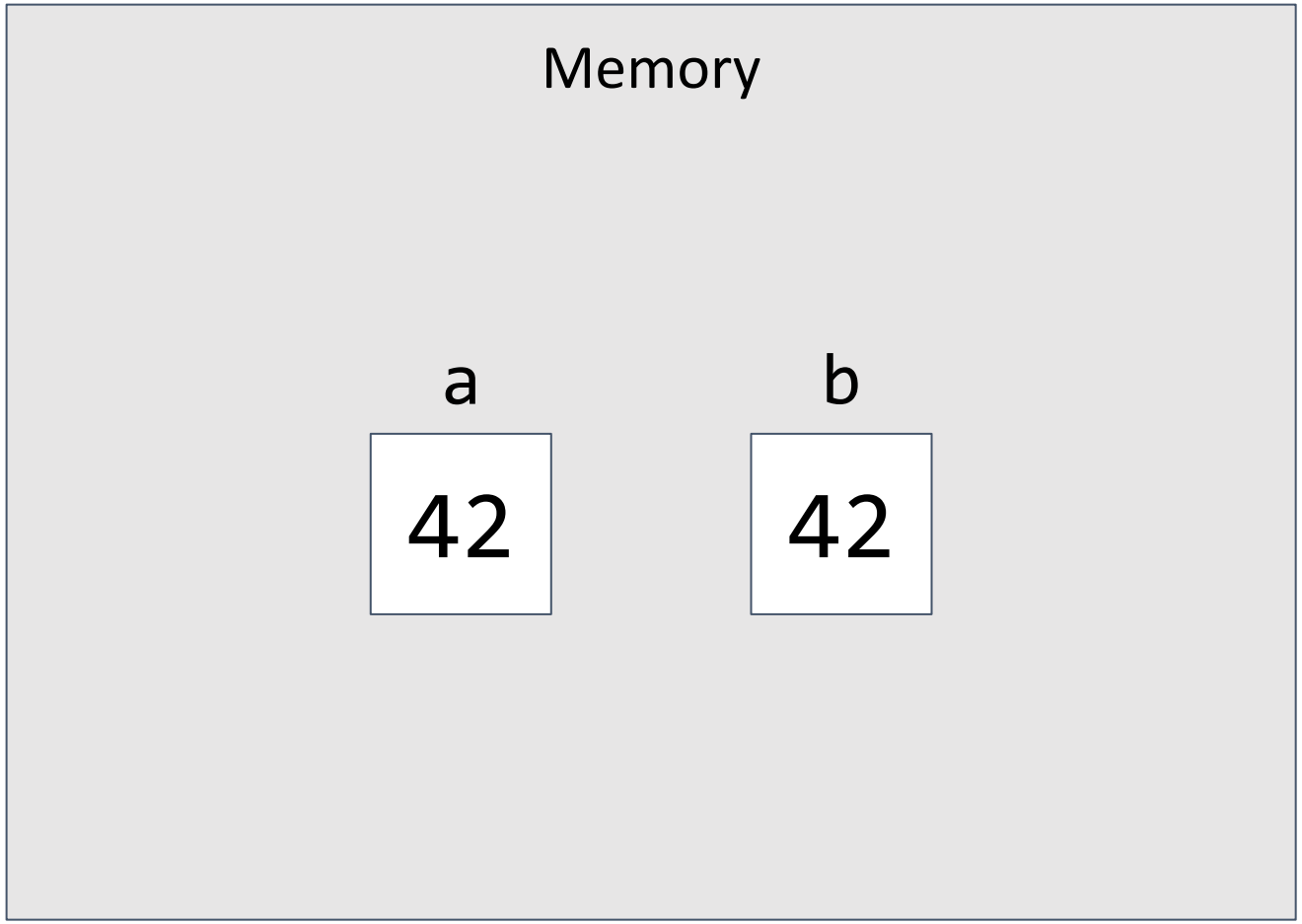

```
In [1]: a = 42
```

Variables Revisited



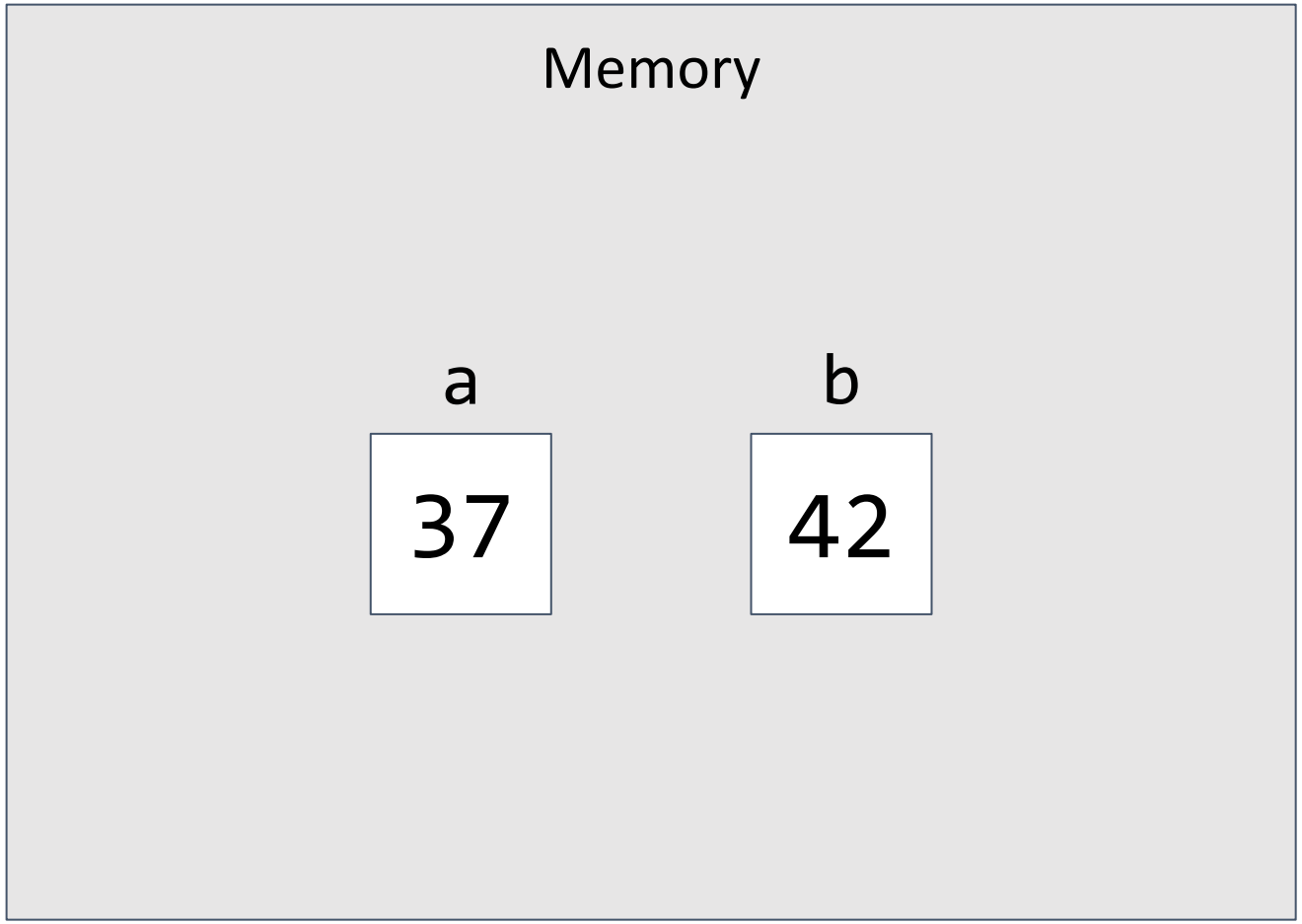

```
In [1]: a = 42

In [2]: b = a
```

Variables Revisited



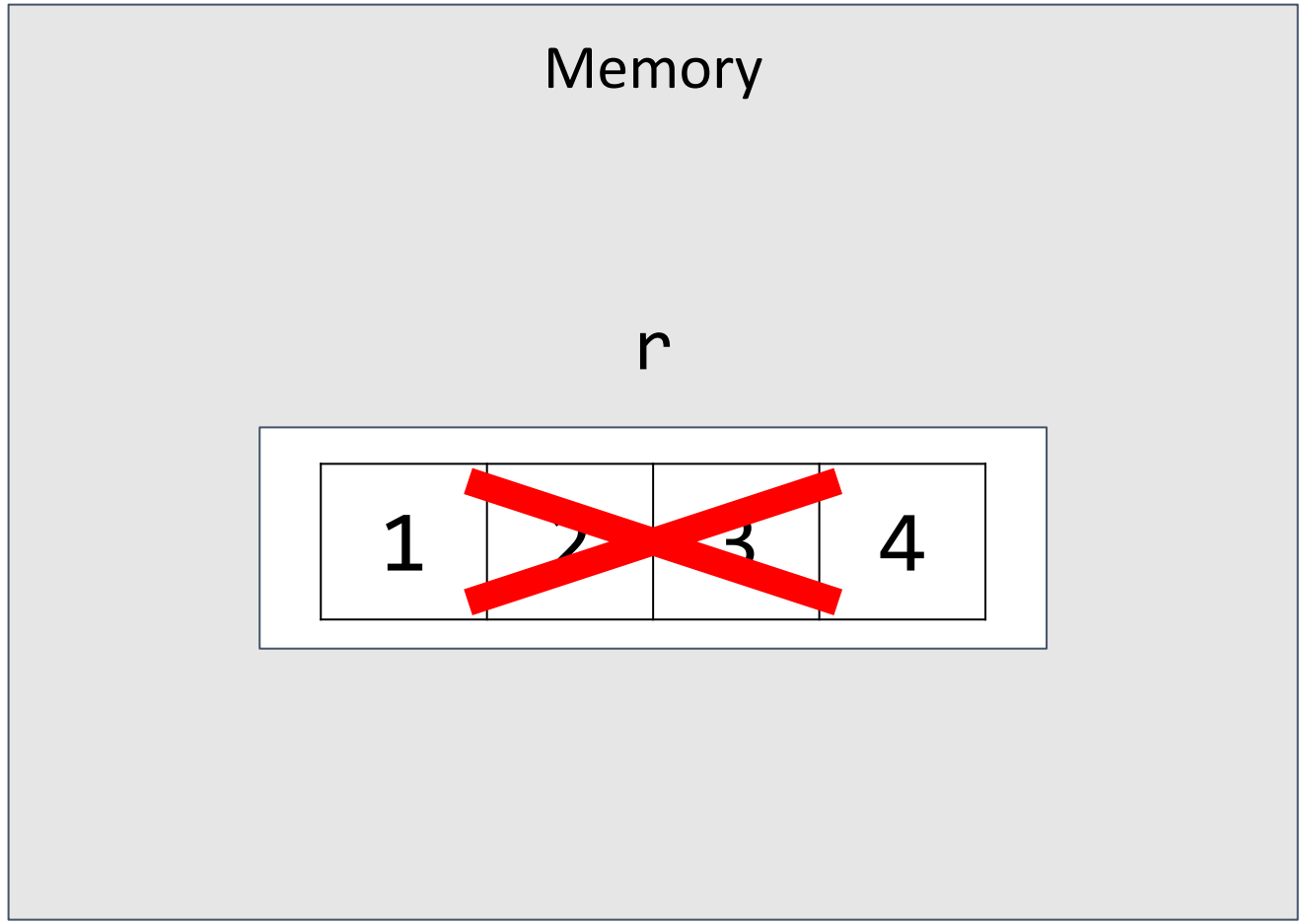

```
In [1]: a = 42

In [2]: b = a

In [3]: a = 37
```

Variables Revisited



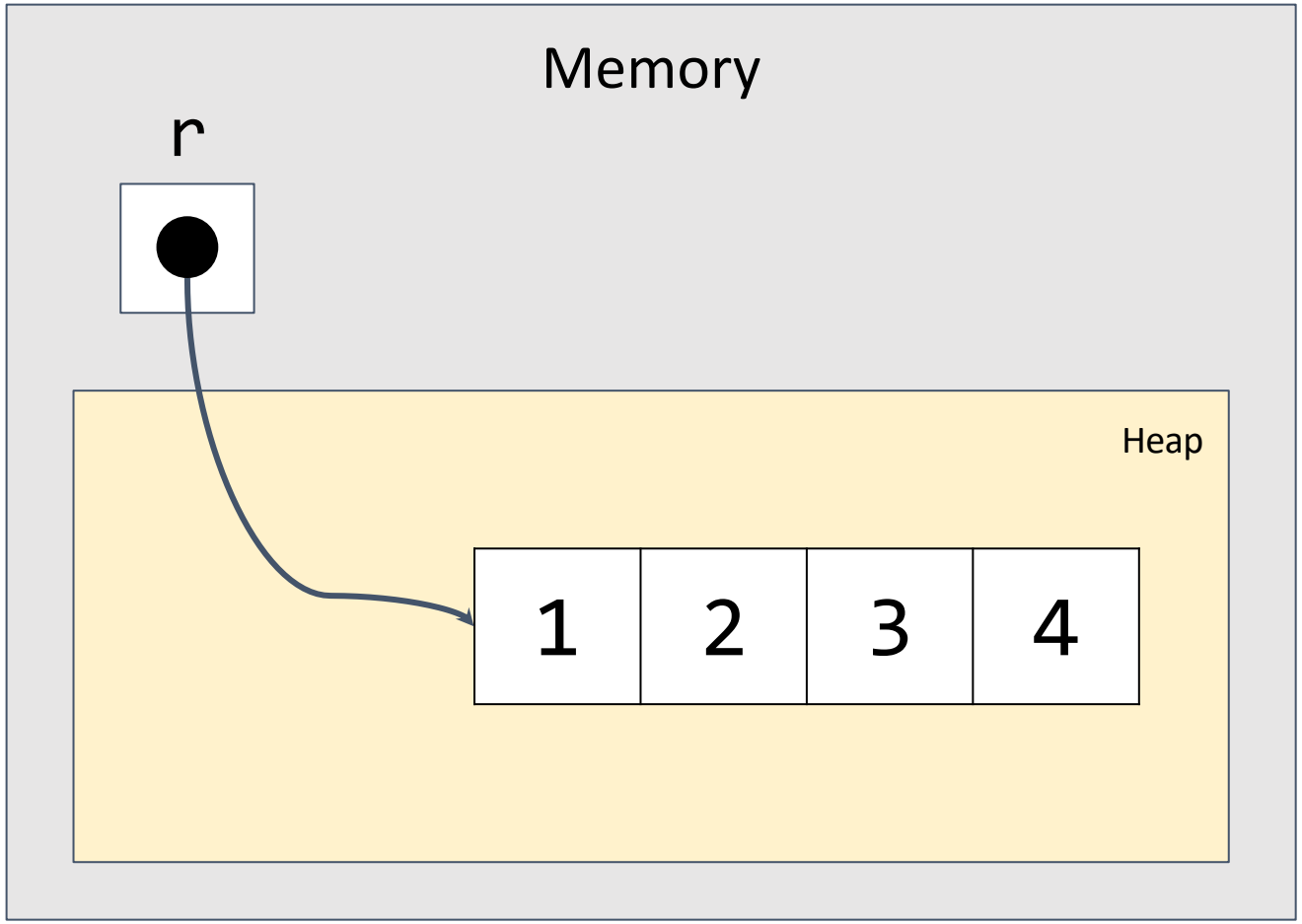

```
In [1]: a = 42

In [2]: b = a

In [3]: a = 37
```

List variables



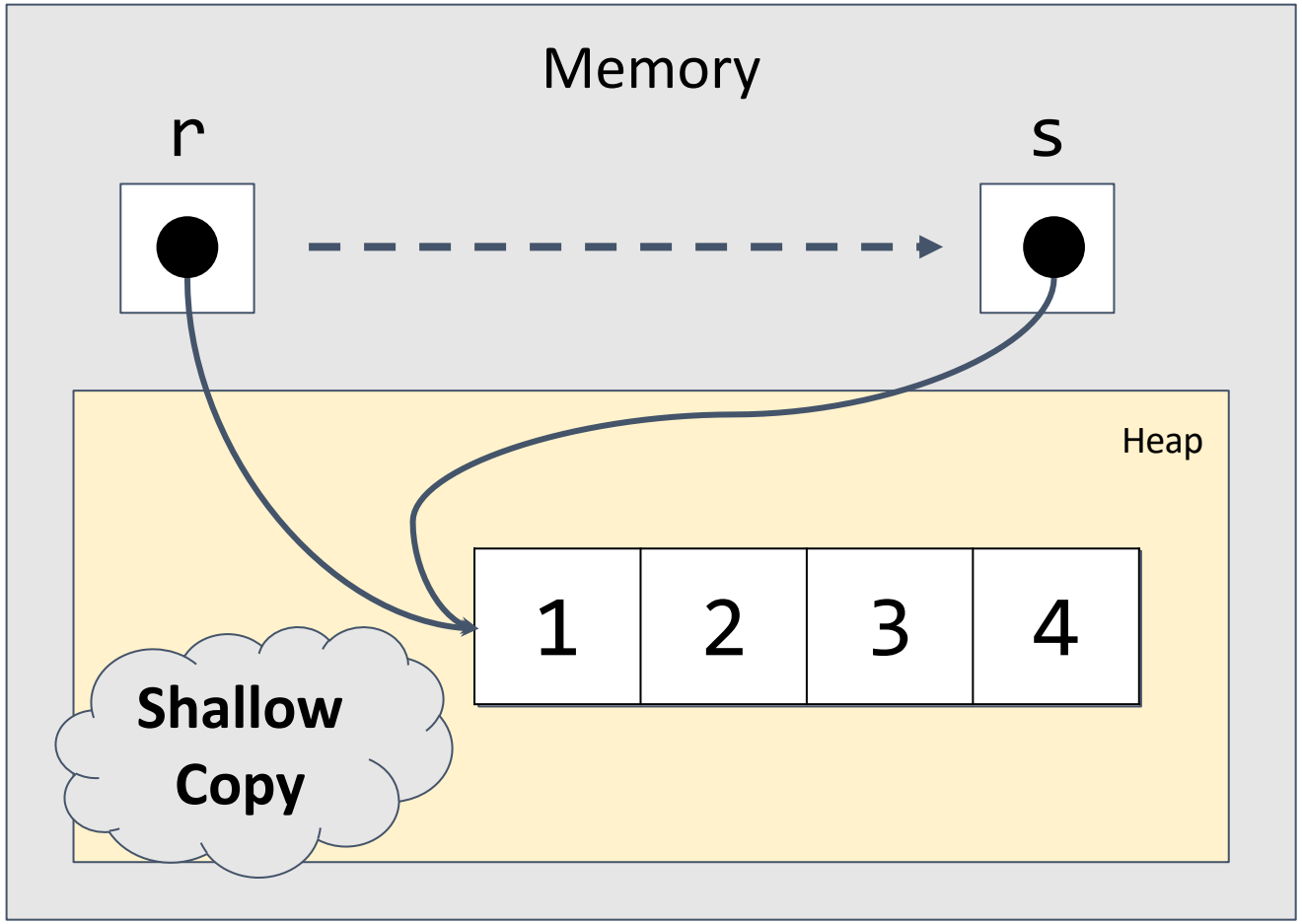

```
In [1]: r = [1, 2, 3, 4]
```

List variables



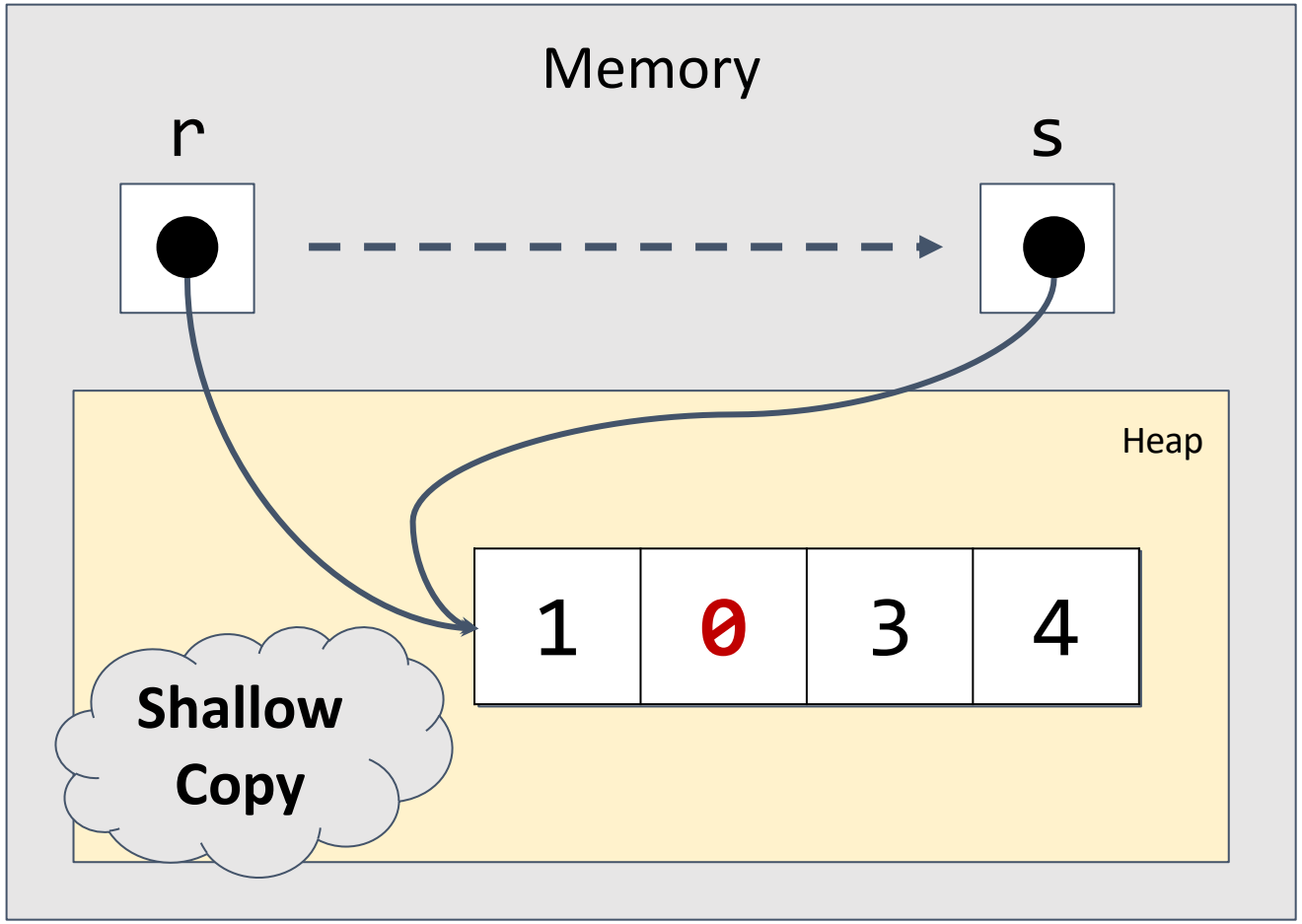

```
In [1]: r = [1, 2, 3, 4]
```

List variables




```
In [1]: r = [1, 2, 3, 4]

In [2]: s = r
```

List variables




```
In [1]: r = [1, 2, 3, 4]

In [2]: s = r
```

```
r[1] = 0
```

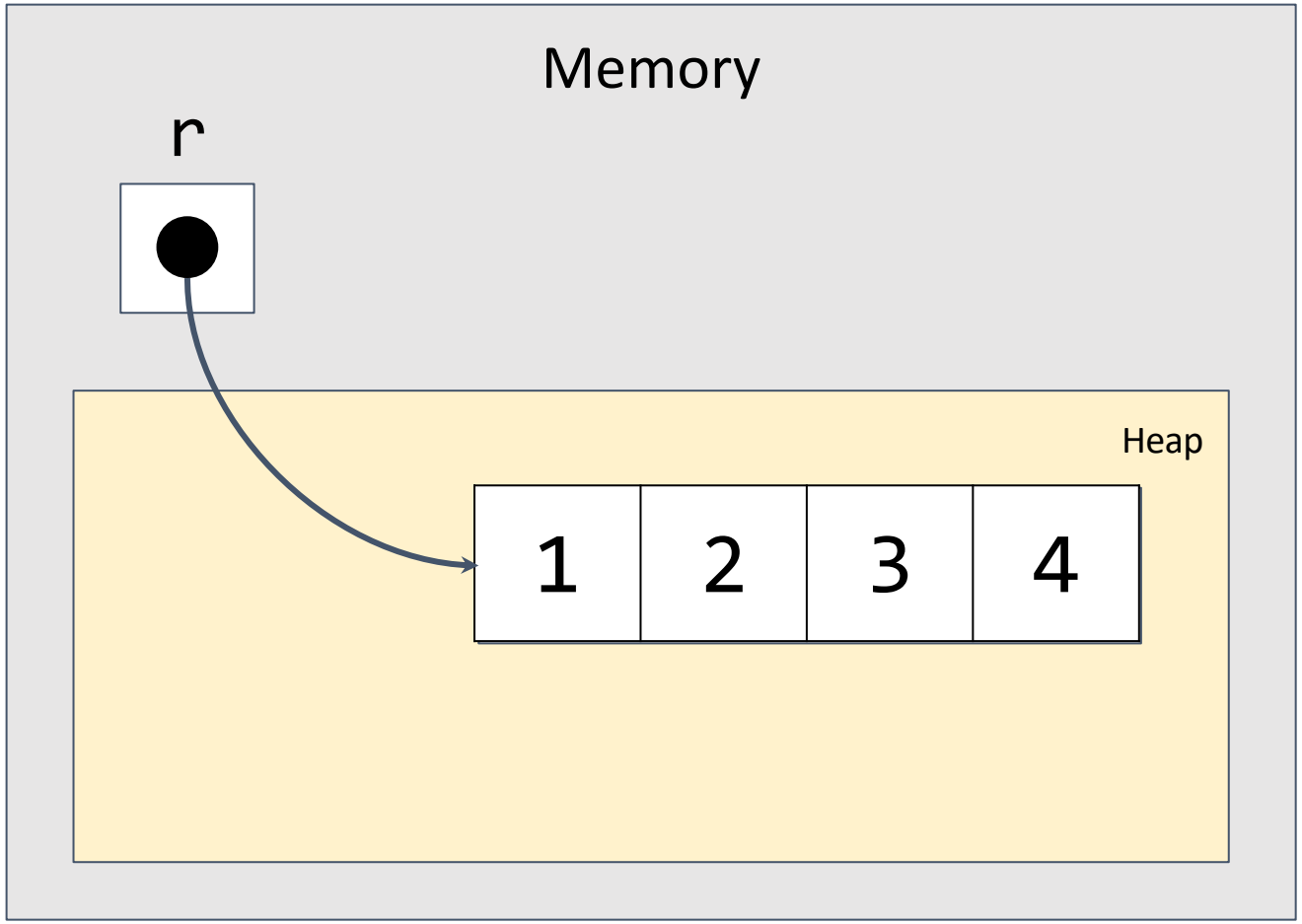
```
1  r
```

```
[1, 0, 3, 4]
```

```
1  s
```

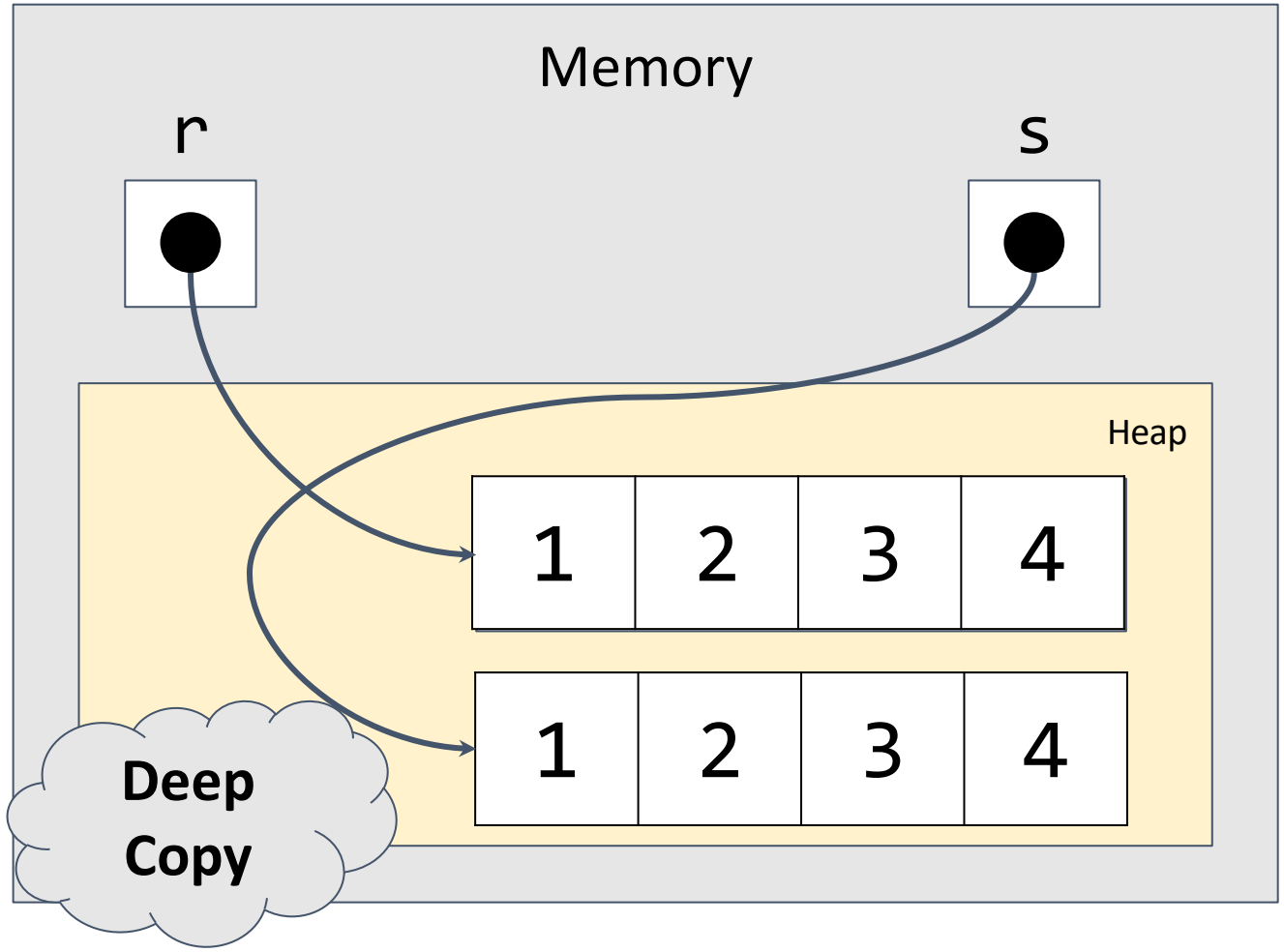
```
[1, 0, 3, 4]
```

List variables




```
In [1]: r = [1, 2, 3, 4]
```

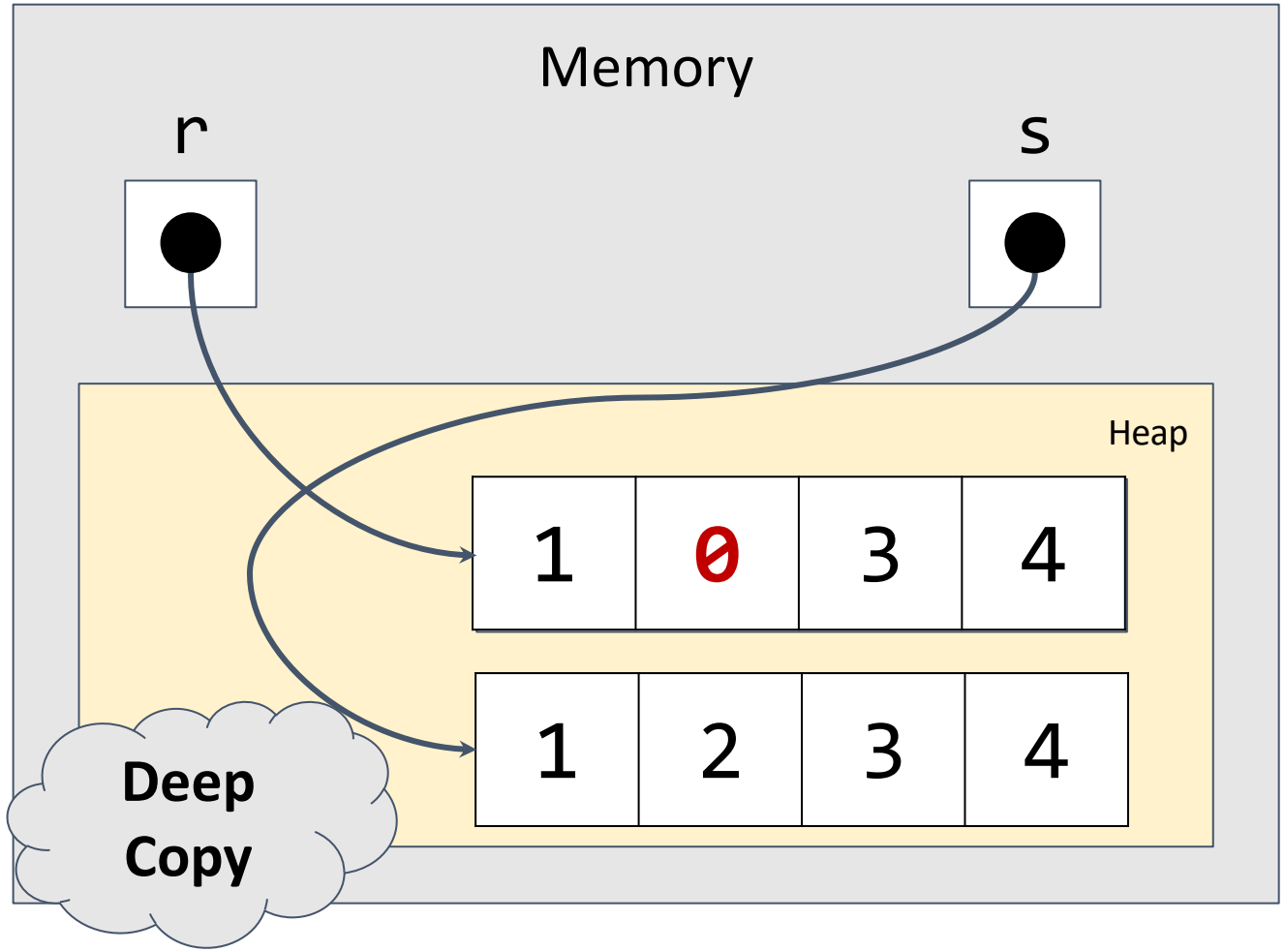
List variables




```
In [1]: r = [1, 2, 3, 4]

In [2]: s = r[:]
```

Can think of this as a 'clone' if that's helpful!

List variables




```
In [1]: r = [1, 2, 3, 4]

In [2]: s = r[:]
```

```
r[1] = 0
```

```
1  r
```

```
[1, 0, 3, 4]
```

```
1  s
```

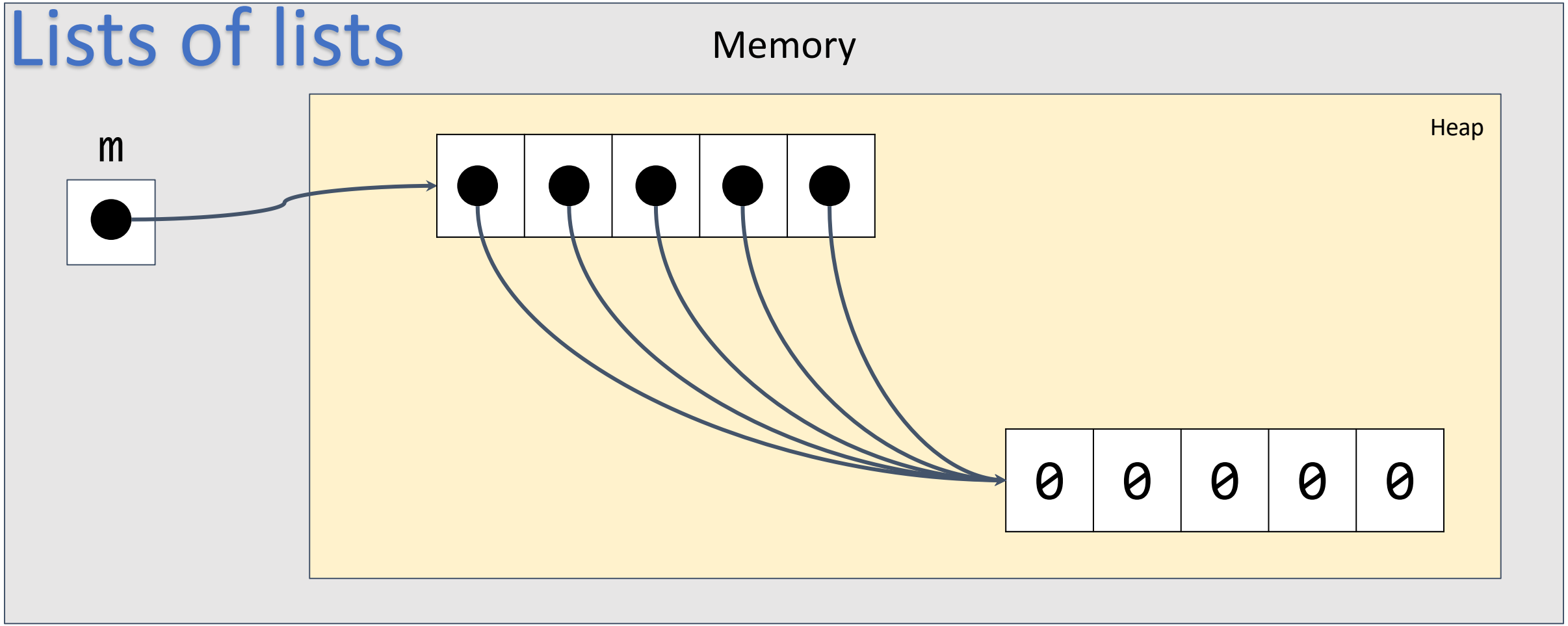
```
[1, 2, 3, 4]
```

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



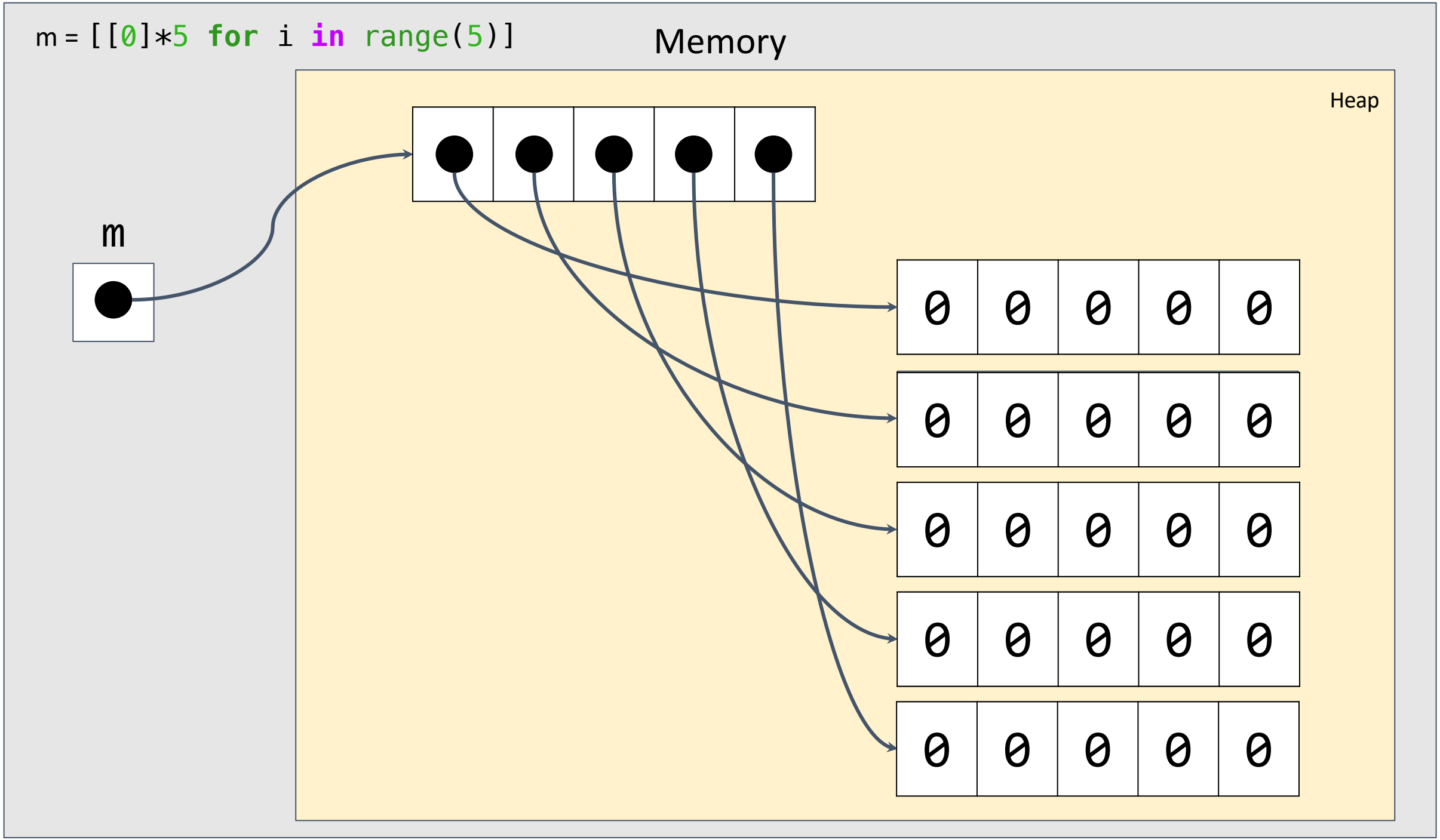

```
m = [[0]*5]*5
```

```
[[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]]
```

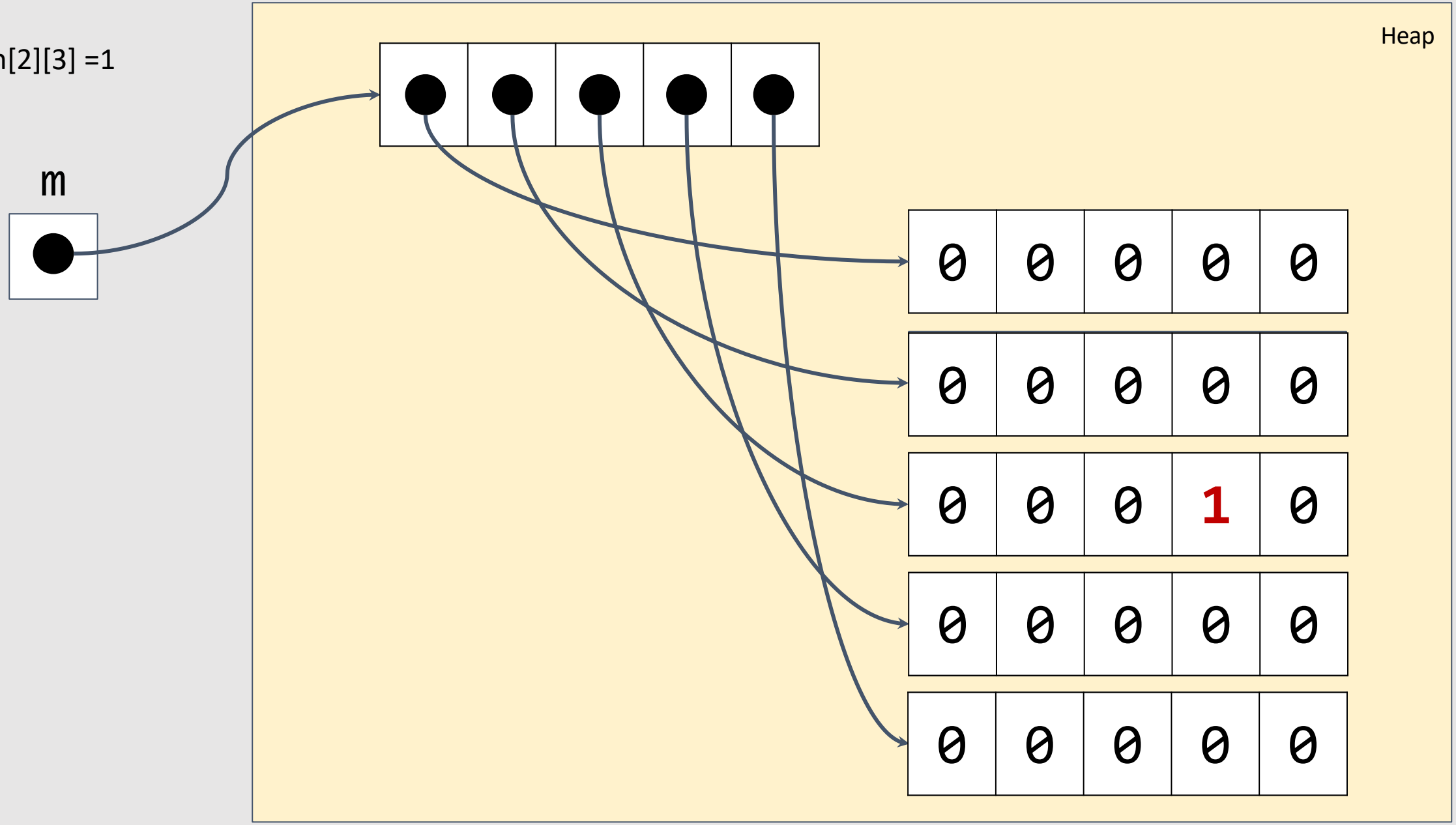
```
m = [[0]*5 for i in range(5)]
```

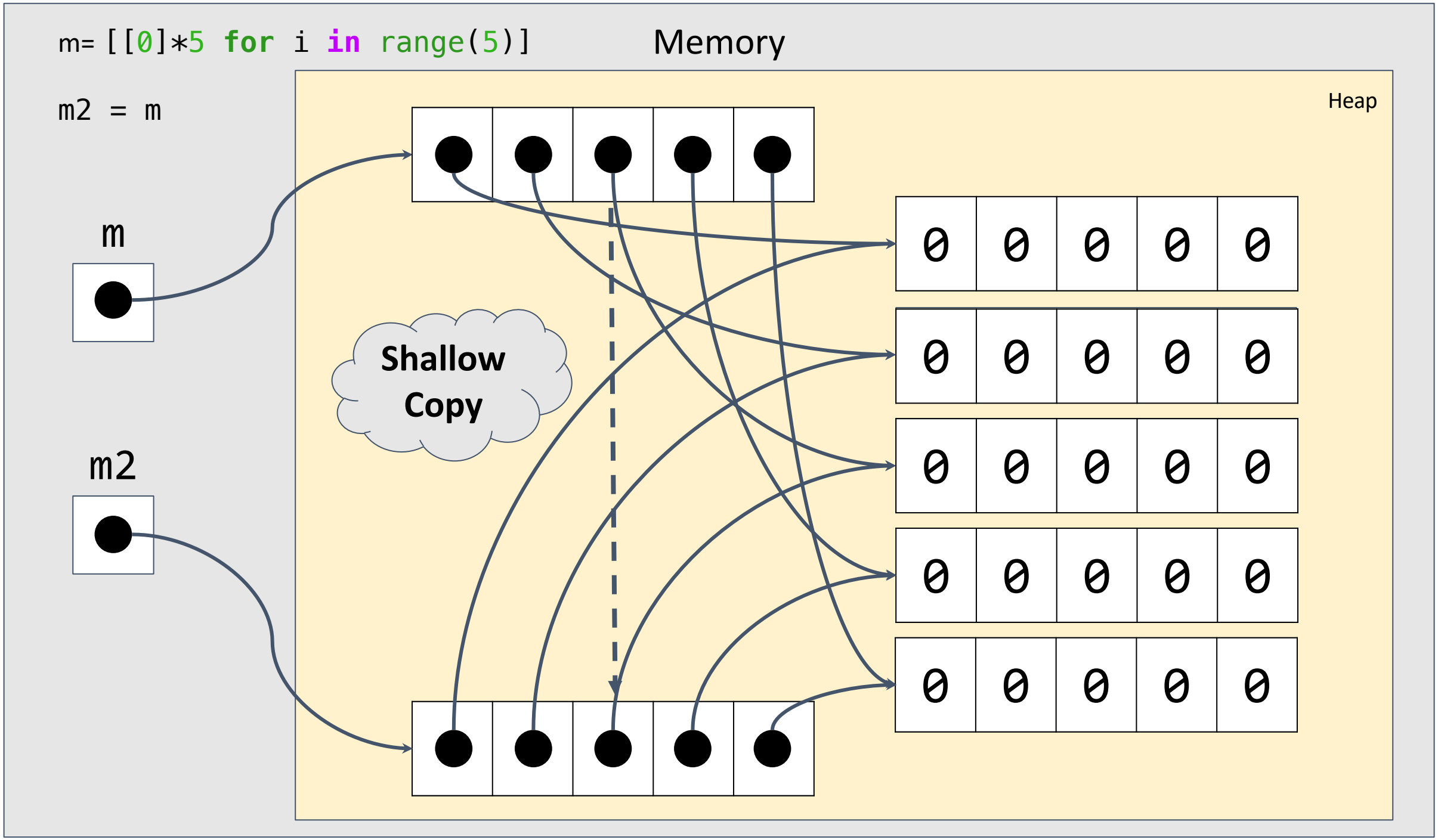


```
m = [[0]*5 for i in range(5)]
```

Memory

m[2][3] =1

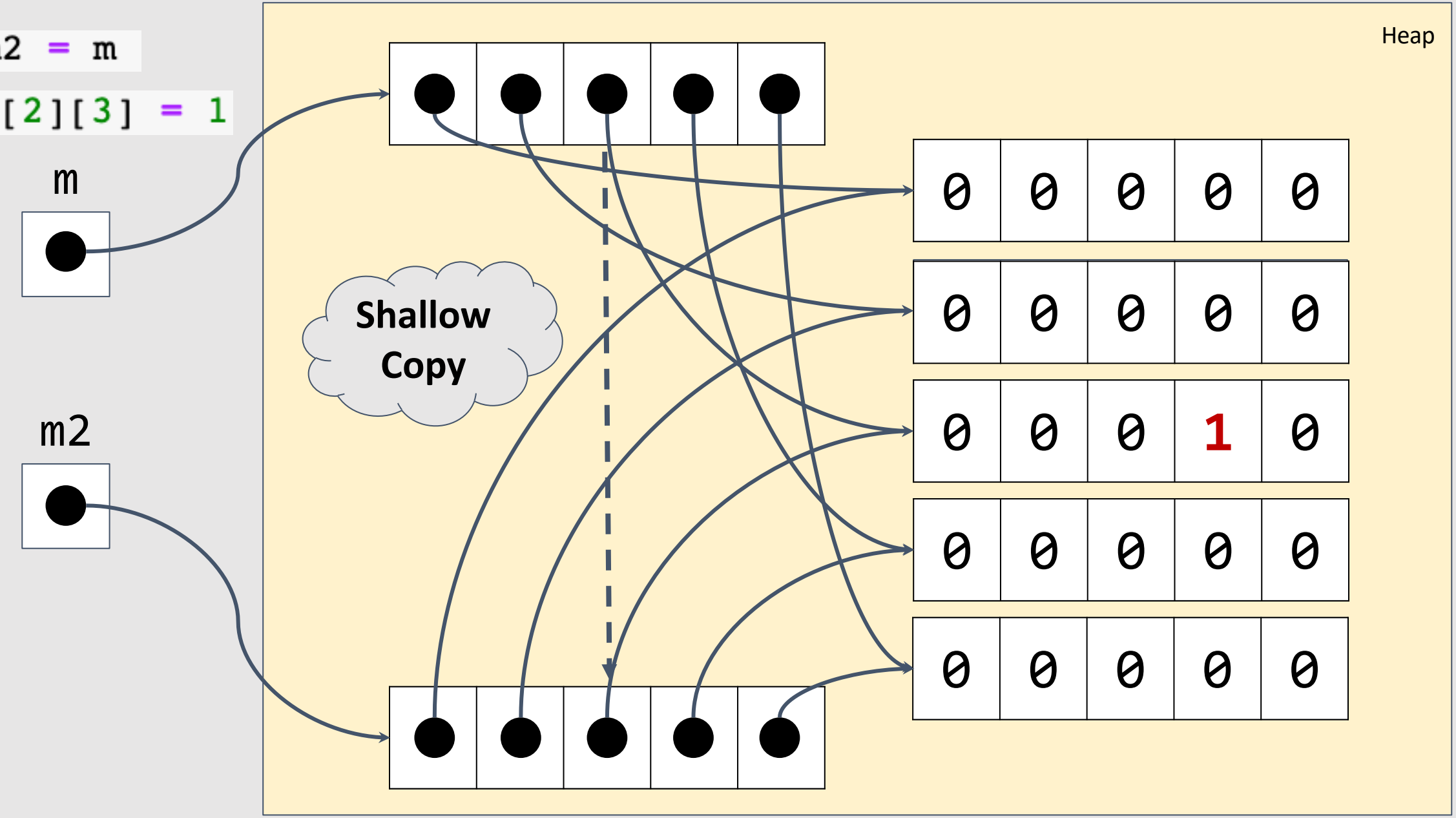



m= [[0]*5 for i in range(5)]
Memory
m2 = m
Heap
m
m2
Shallow Copy
0 0 0 0 0
0 0 0 0 0
0 0 0 0 0
0 0 0 0 0
0 0 0 0 0

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

Memory

```
m2 = m
m[2][3] = 1
```



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?

TT2: anatomy of a project

- We'll go more into functions come Tuesday
- Good to start working through TT to see what questions are coming up
- Items:
  - TT files (linked on Canvas)
    - geometry
    - list_exercises
    - min_max
  - Walkthrough (on course page): https://classes.ssd.uchicago.edu/macss/macs30121/modules/tt/tt2.html

TT2: anatomy of a project

- Suggested workflow:
    - Follow along with page
    - Try it all on your own (pretend solutions do not exist! Resist temptation!)
    - Read through and compare your solution to the published solution – how are they different? What does that mean about your code?

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.

TT2: checking in + workflow

- Talk with partner
- Work on Ed discussion

PA 1: IT’S COMING!!!

- MULTIPLE STEPS
- TIME CONSUMING
- NEED GOOD WORKFLOW
- START NOW!!!
    - I suggest doing the first four tasks in groups of two
    - Task 5 will likely take awhile to go back and ensure everything comes together

Looking ahead: next class / deadlines

- 10/6 Friday: SE 2
- 10/9 Monday: SE 2 reflection
- 10/13 Friday PA 1
- 10/16 Monday PA 1 reflection

- **Content: Read up on functions Ch 1.4**