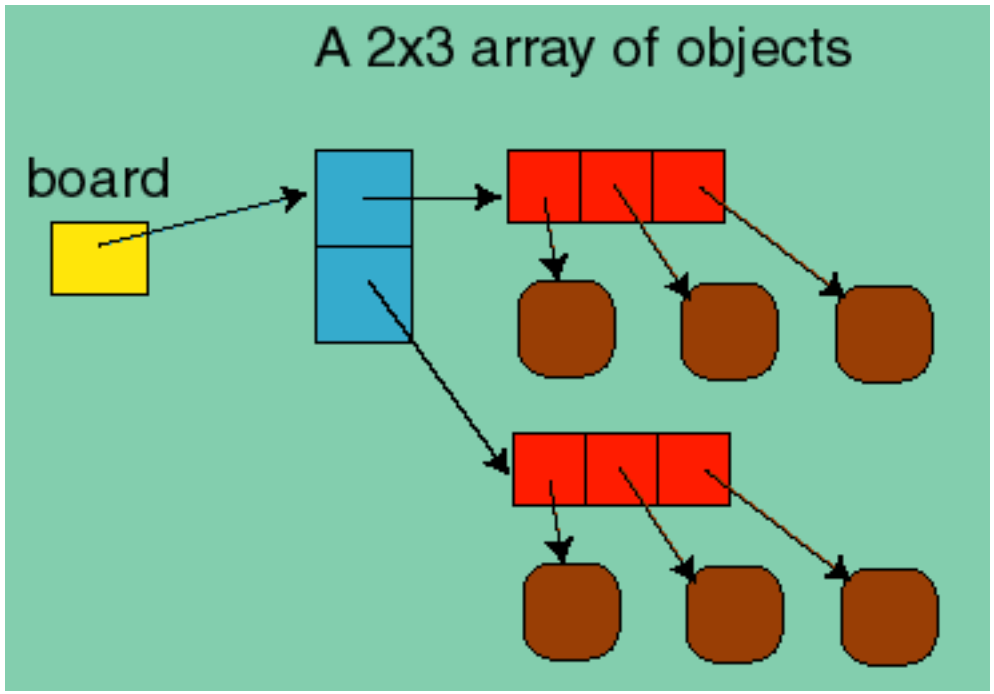
SAMS
Programming - Section C

Week 4 - Lecture 1:
"2-dimensional" lists



July 24, 2017

Pop Quiz

Pop Quiz

Fill in the blank:

Lists are awesome .

T/F: A variable stores the value of an object.

T/F: To make a copy of the list a = [1, 2, 3], do

```
b = a       # a and b are aliases
b = copy.copy(a)
```

What will the following print?

```
a = [1, 2, 3]
b = copy.copy(a)
print(a == b, a is b)
```

Pop Quiz

Fill in the blank:

List parameters and arguments are awesome .

Pop Quiz

Fill in the blank:

List parameters and arguments are awesome .

```
def fill(a, value):
    for i in range(len(a)):
        a[i] = value
```

Destructive function

```
x = [1, 2, 3]
fill(x, 42)
print(x)
```

[42, 42, 42]

Pop Quiz

Fill in the blank:

List parameters and arguments are awesome .

```
def fill(a, value):
    a = copy.copy(a)
    for i in range(len(a)):
        a[i] = value
    return a

x = [1, 2, 3]
y = fill(x, 42)
print(x, y)
```

Nondestructive version

[1, 2, 3] [42, 42, 42]

Pop Quiz

Is the sorted function destructive?

```
a = [5, 4, 3, 2, 1]
b = sorted(a)
print(a, b)
```

[5, 4, 3, 2, 1] [1, 2, 3, 4, 5]

Is the sort method destructive?

```
a = [5, 4, 3, 2, 1]
b = a.sort()
print(a, b)
```

[1, 2, 3, 4, 5] None

Pop Quiz

How do you convert a string to a list?

```
s = “You suck anil!”
print(list(s))   ['Y', 'o', 'u', ' ', 's', 'u', 'c', 'k', ' ', 'a', 'n', 'i', 'l', '!']
print(s.split(“ ”))     ['You', 'suck', 'anil!']
```

How do you convert a list of strings into one string?

```
a = [“Stephen”, “is”, “awesome”]
print(“”.join(a))        Stephenisawesome
print(“ ”.join(a))       Stephen is awesome
print(“,”.join(a))       Stephen,is,awesome
```

Pop Quiz

What does this print?

```
a = [1, 2, 3]
b = a
a = a + [4]
print(a)        [1, 2, 3, 4]
print(b)        [1, 2, 3]
```

What does this print?

```
a = [1, 2, 3]
b = a
a += [4]
print(a)        [1, 2, 3, 4]
print(b)        [1, 2, 3, 4]
```

Pop Quiz

What is the difference between pop and other destructive methods?

It makes a cool sound.

Pop Quiz

What is the difference between pop and other destructive methods?

It returns something.

“2d lists”

"2d lists"

A list can contain any type of object.

```
a = [1, "hello", False]
```

Can also contain lists.

```
a = [[1, 3, 5], [6], [1, 5]]          # A list of lists

print(len(a))        3
```

a[0] is a reference to the first list [1, 3, 5]

a[1] is a reference to the second list [6]

a[2] is a reference to the third list [1, 5]

a[0][0] is a reference to the first element of the first list [1, 3, 5]

a[2][1] is a reference to the second element of the third list [1, 5]

Example: Print all the elements

```
a = [[1, 3, 5], [6], [1, 5]]
```

```
a = [ [1, 3, 5],
      [6],
      [1, 5]
    ]
```

Looping through the elements one by one:

```
for i in range(len(a)):
    for j in range(len(a[i])):
        print(a[i][j])
```

```
1
3
5
6
1
5
```

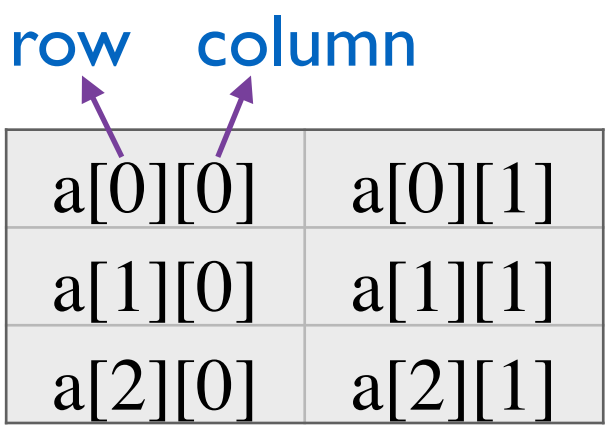
rectangular "2d list"

Most "2d lists" we deal with will have same length sublists.

```
a = [[1, 3], [2, 4], [1, 5]]
```

```
a = [ [1, 3],
      [2, 4],
      [1, 5]
    ]
```

Really like a table (or matrix)



2d list examples

A chess board: 8 lists of length 8 each (or 8 by 8 table)

Each entry either contains a chess piece or is empty.

An image: a 2d list of points/pixels

Each entry contains the color of the point.

A database: e.g. a list of users and various information about the users

Cool. Seems easy enough. Can we go home?

Unfortunately, no. 

Tricky thing about 2d lists

1d list: references to **immutable** objects.

Aliases of elements not a problem.

2d list: references to **mutable** objects.

We must be careful about aliases of elements !!

"Weird" Example 1

```
a = [1, 2, 3]
b = copy.copy(a)
b[0] = 0
print(a)        [1, 2, 3]
print(b)        [0, 2, 3]
```

```
a = [[1, 2, 3], [4, 5, 6]]
b = copy.copy(a)
b[0][0] = 0
print(a)        [ [0, 2, 3], [4, 5, 6] ]
print(b)        [ [0, 2, 3], [4, 5, 6] ]
```

“Weird” Example 2

```
a = [ [0]*2 ]*3
print(a)
```

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

```
a[0][0] = 9

print(a)
```

[[9, 0], [9, 0], [9, 0]]

Understanding Example 1

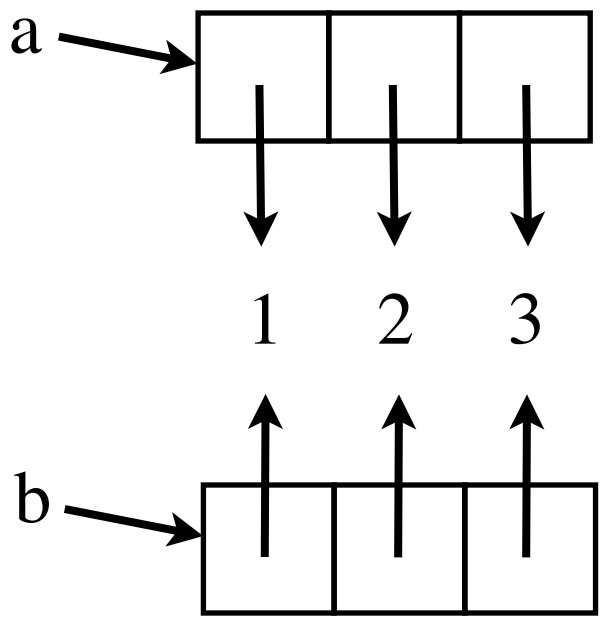
```
a = [1, 2, 3]

b = copy.copy(a)

b[0] = 0

print(a[0])

print(b[0])
```



Making a copy of the references.

Understanding Example 1

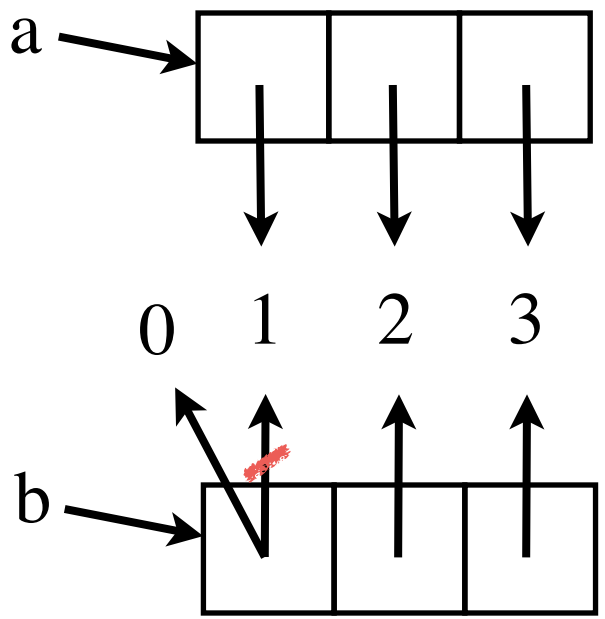
```
a = [1, 2, 3]

b = copy.copy(a)

b[0] = 0

print(a[0])

print(b[0])
```



Making a copy of the references.

Understanding Example 1

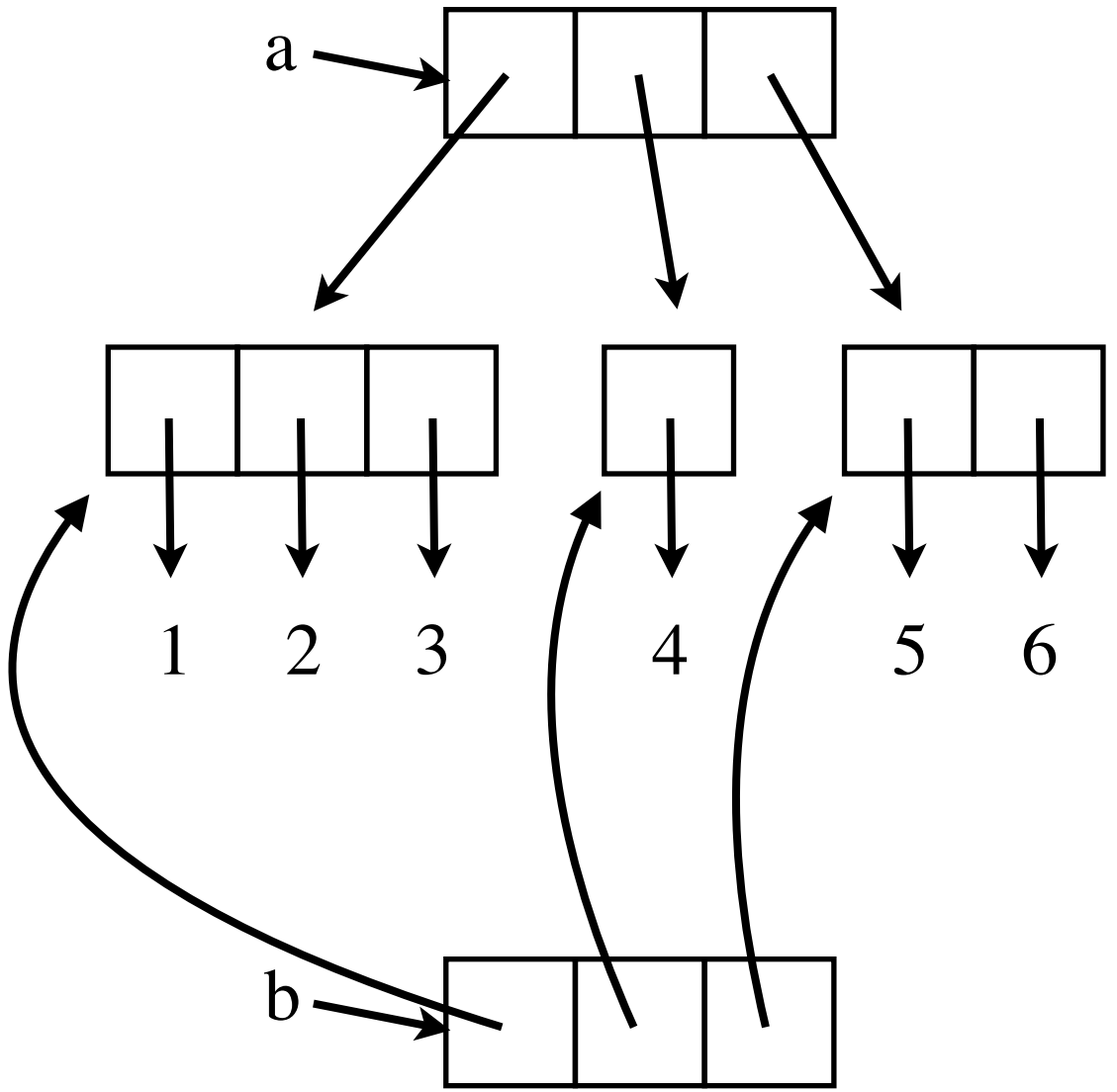
```
a = [[1, 2, 3], [4], [5, 6]]

b = copy.copy(a)

b[0][0] = 0

print(a[0][0])

print(b[0][0])
```



Understanding Example 1

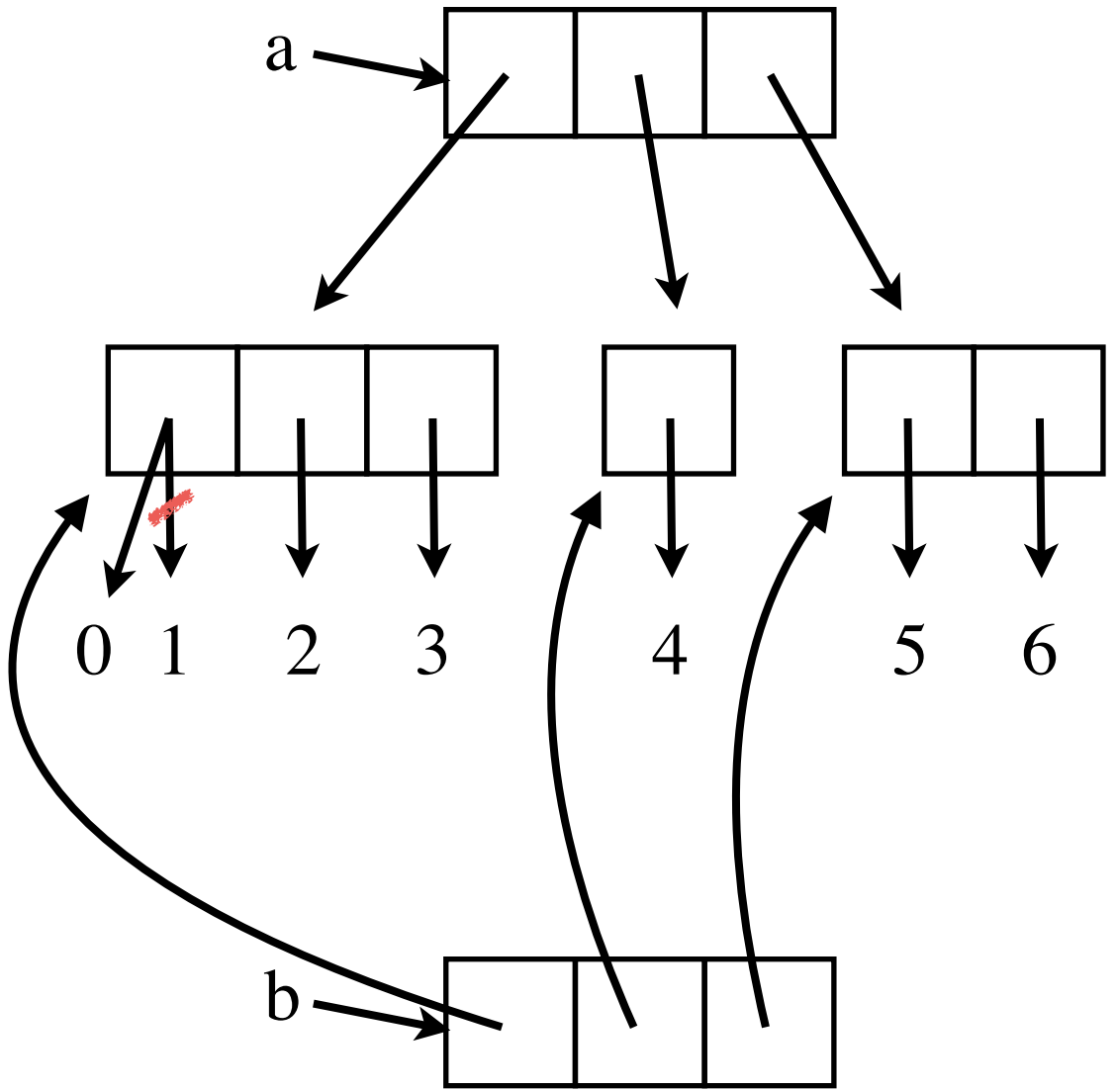
```
a = [[1, 2, 3], [4], [5, 6]]

b = copy.copy(a)

b[0][0] = 0

print(a[0][0])

print(b[0][0])
```



Understanding Example 1

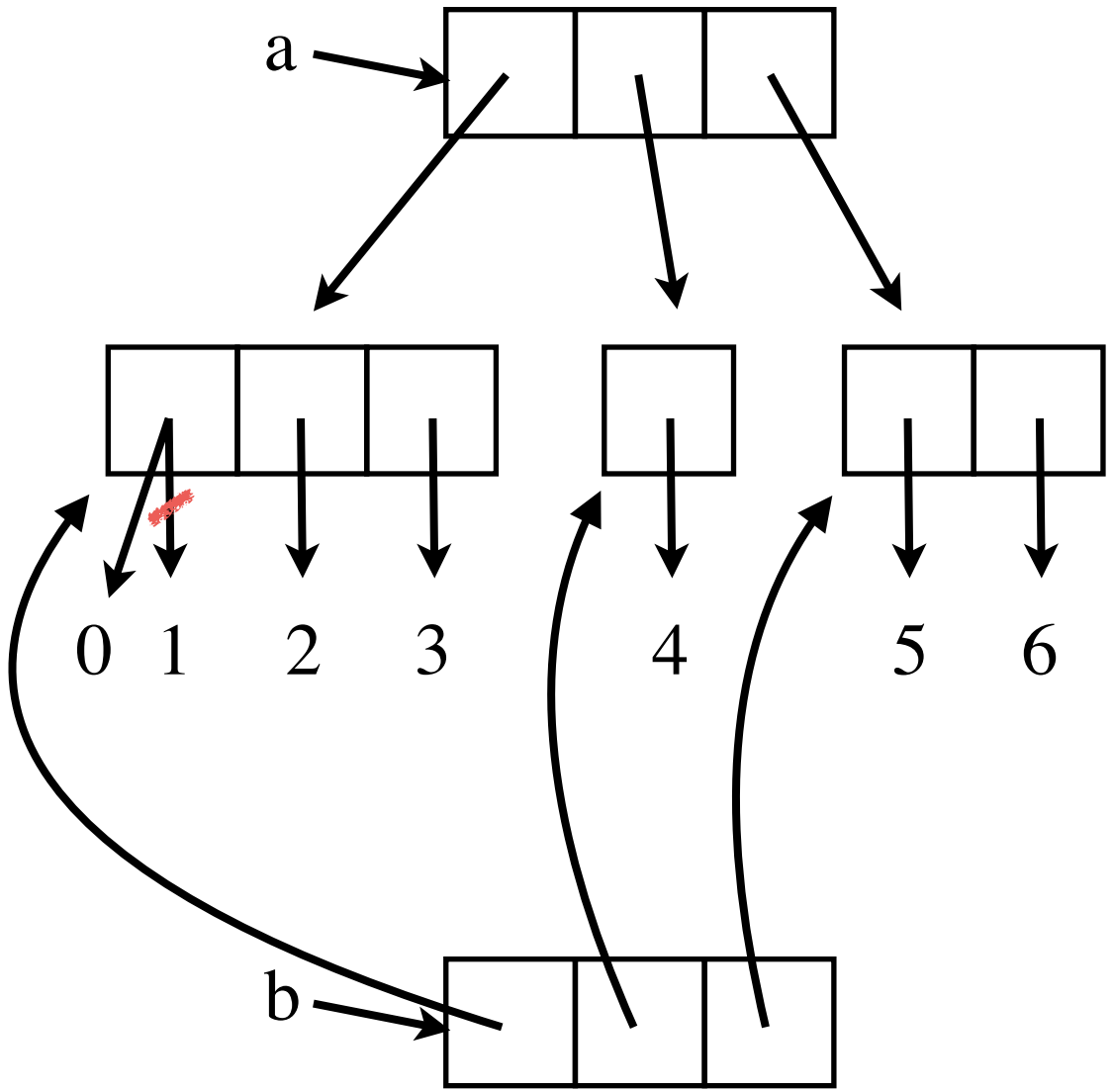
```
a = [[1, 2, 3], [4], [5, 6]]

b = a[:]

b[0][0] = 0

print(a[0][0])

print(b[0][0])
```



Understanding Example 1

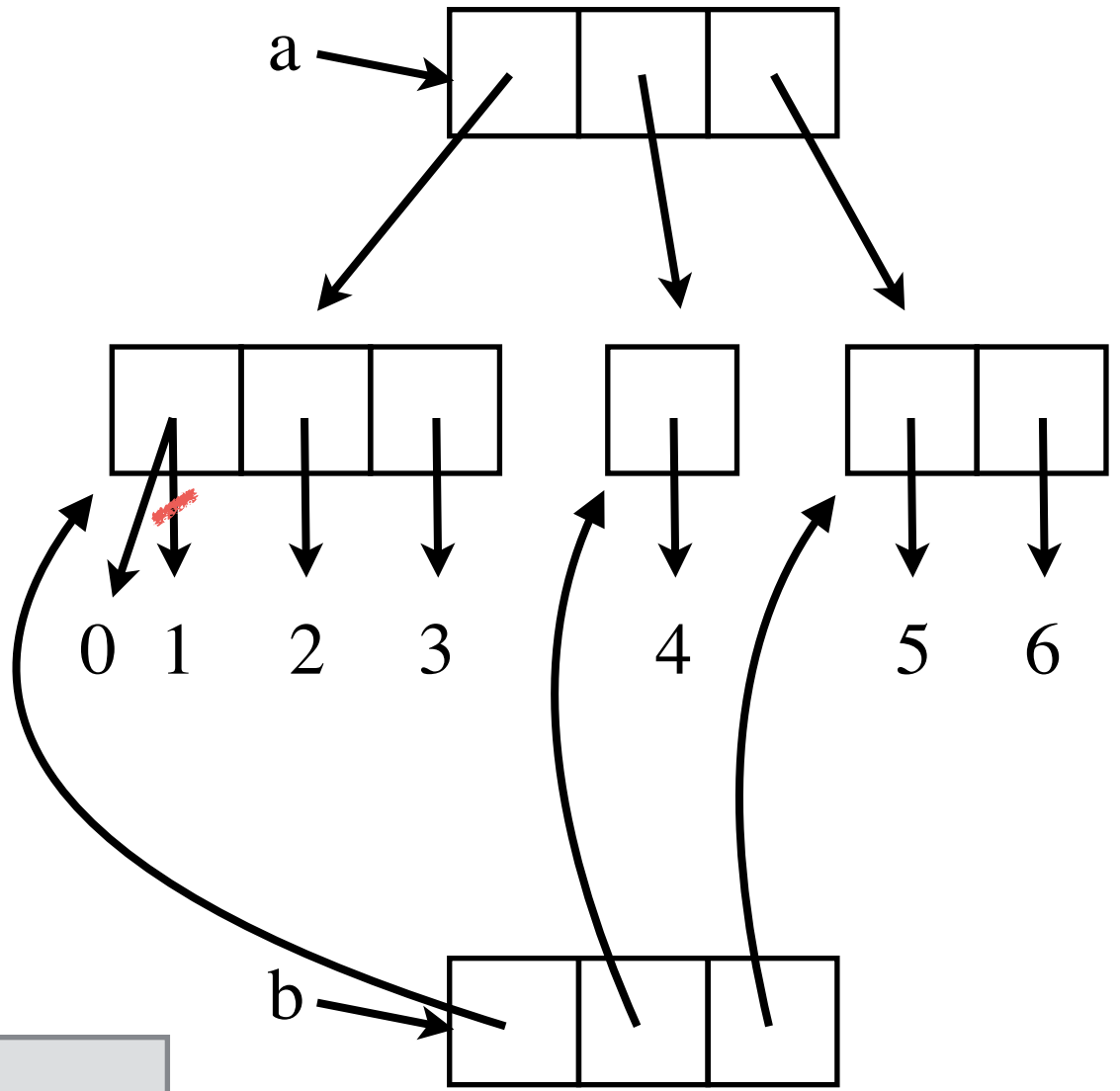
```
a = [[1, 2, 3], [4], [5, 6]]

b = a + []

b[0][0] = 0

print(a[0][0])

print(b[0][0])
```



copy.copy, + and list slices make shallow copies

Understanding Example 1

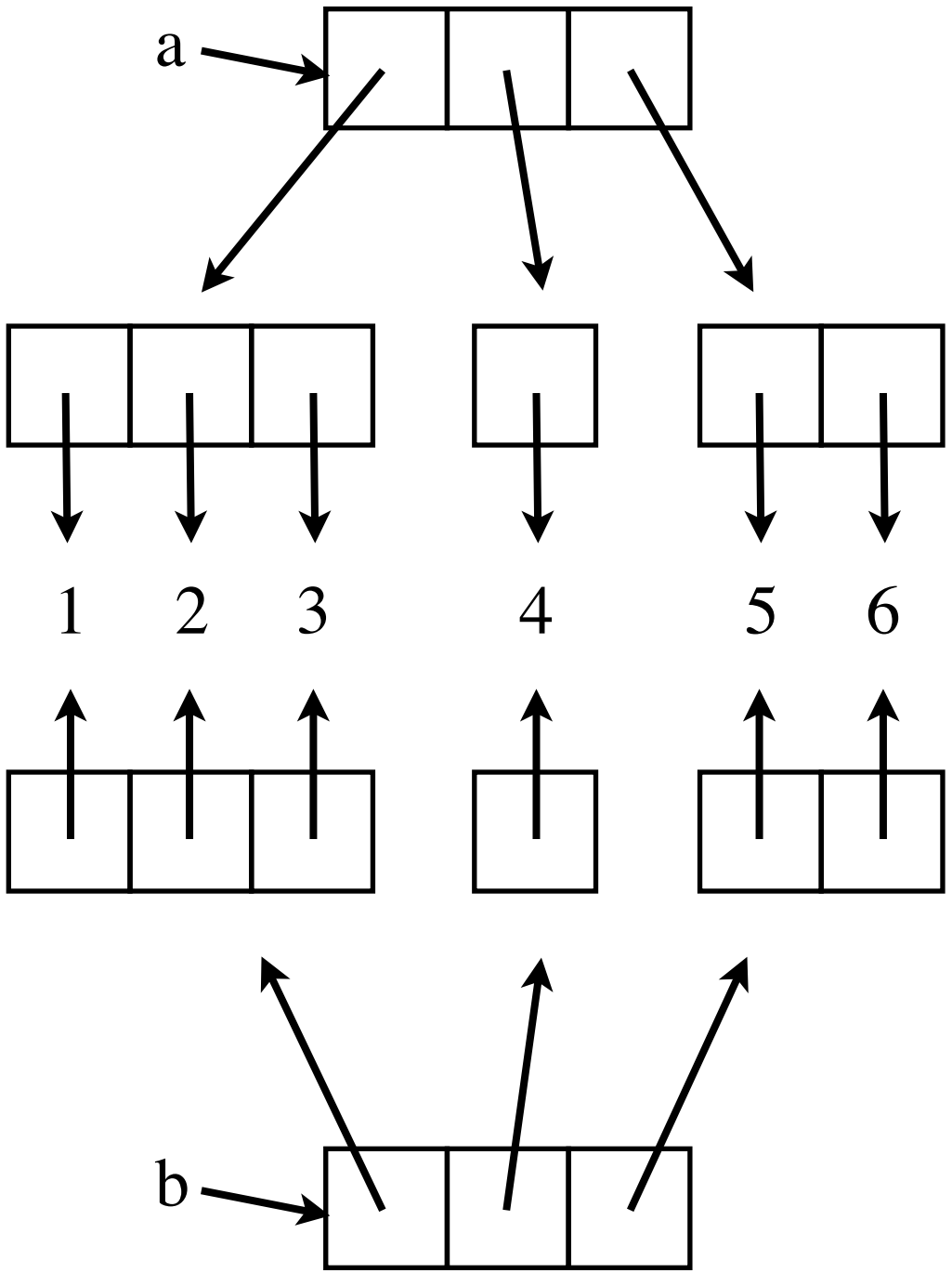
```
a = [[1, 2, 3], [4], [5, 6]]

b = copy.deepcopy(a)

b[0][0] = 0

print(a[0][0])

print(b[0][0])
```



Understanding Example 1

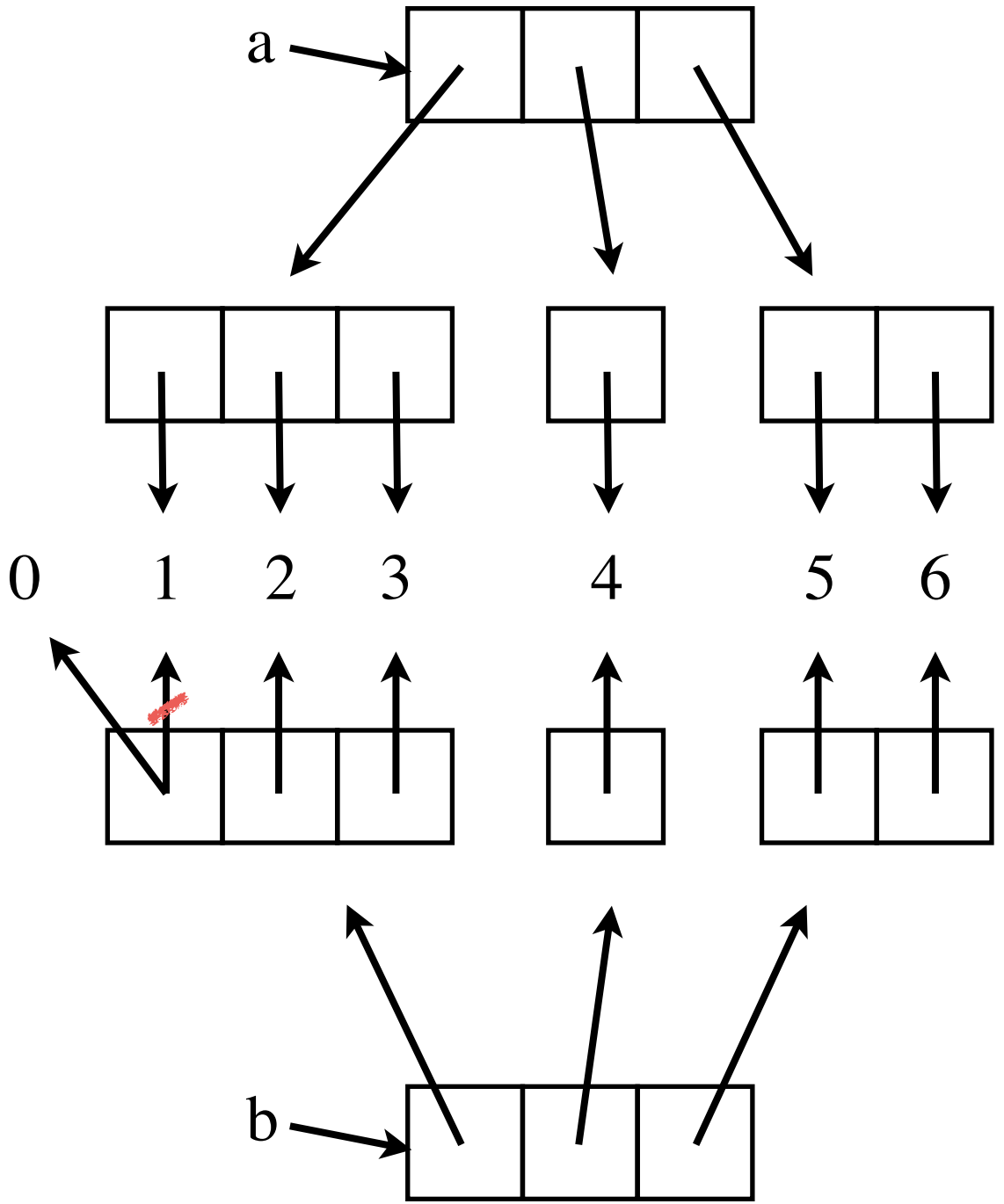
a = [[1, 2, 3], [4], [5, 6]]

b = **copy.deepcopy(a)**

b[0][0] = 0

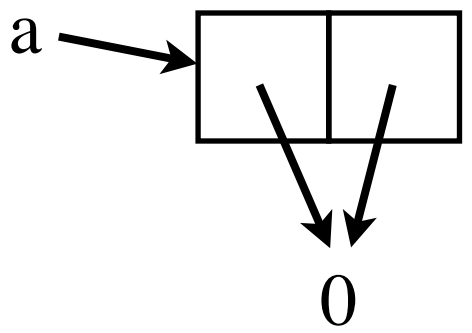
print(a[0][0])

print(b[0][0])



Understanding Example 2

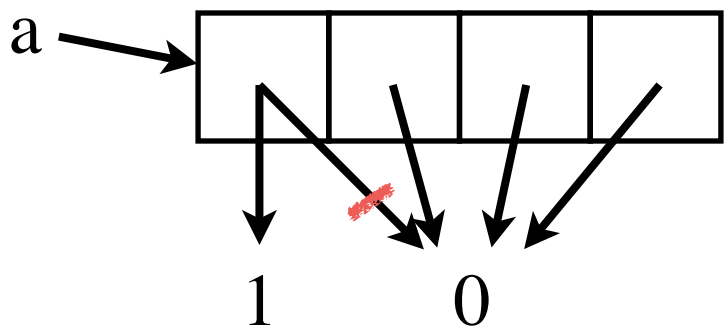
```
a = [0]*2
```



Understanding Example 2

a = [0]*4

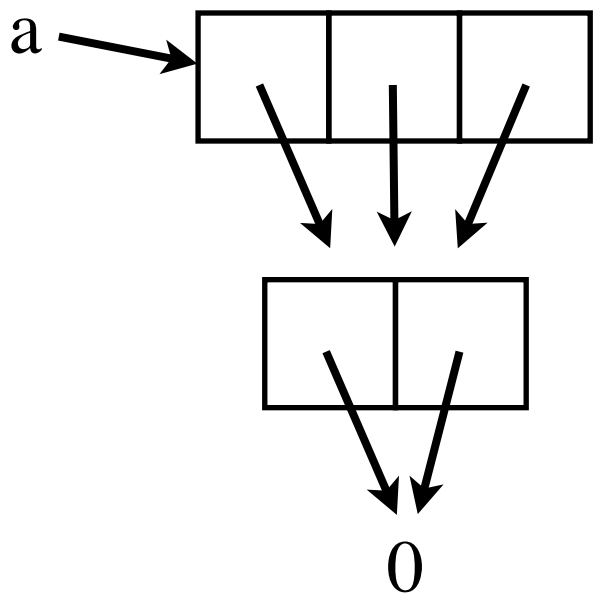
a[0] = 1



Understanding Example 2

 # Create a 3 by 2 list

a = [[0]*2]*3



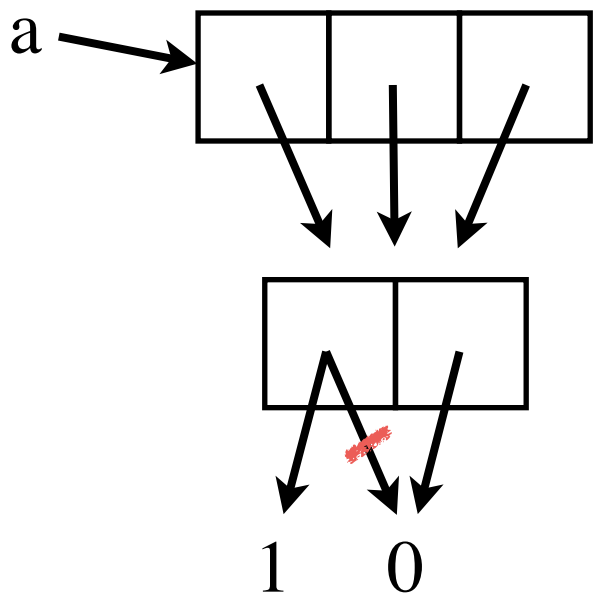
Understanding Example 2

```
# Create a 3 by 2 list
a = [ [0]*2 ]*3
[ [0, 0], [0, 0], [0, 0] ]

a[0][0] = 1

print(a)

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

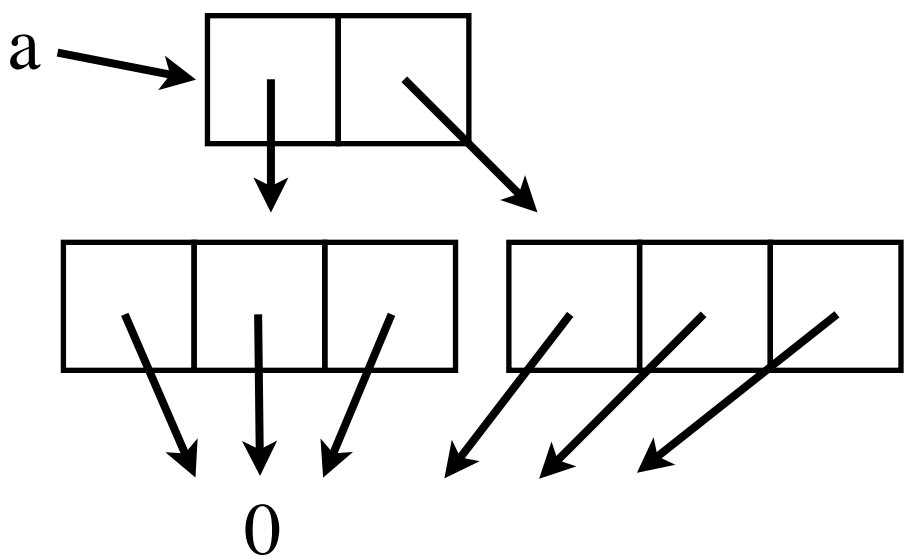


a[0], a[1], and a[2] are aliases !

Creating a *rows* by *cols* 2d list

```
rows = 2
cols = 3
a = [ ]
for row in range(rows):
    a += [[0]*cols]
```

```
a += [[0, 0, 0]]
a += [[0, 0, 0]]
```



Creating a *rows* by *cols* 2d list

Define a function for this task.

```
def make2dList(rows, cols):
    a = []
    for row in range(rows):
        a += [[0]*cols]
    return a
```

One more important thing

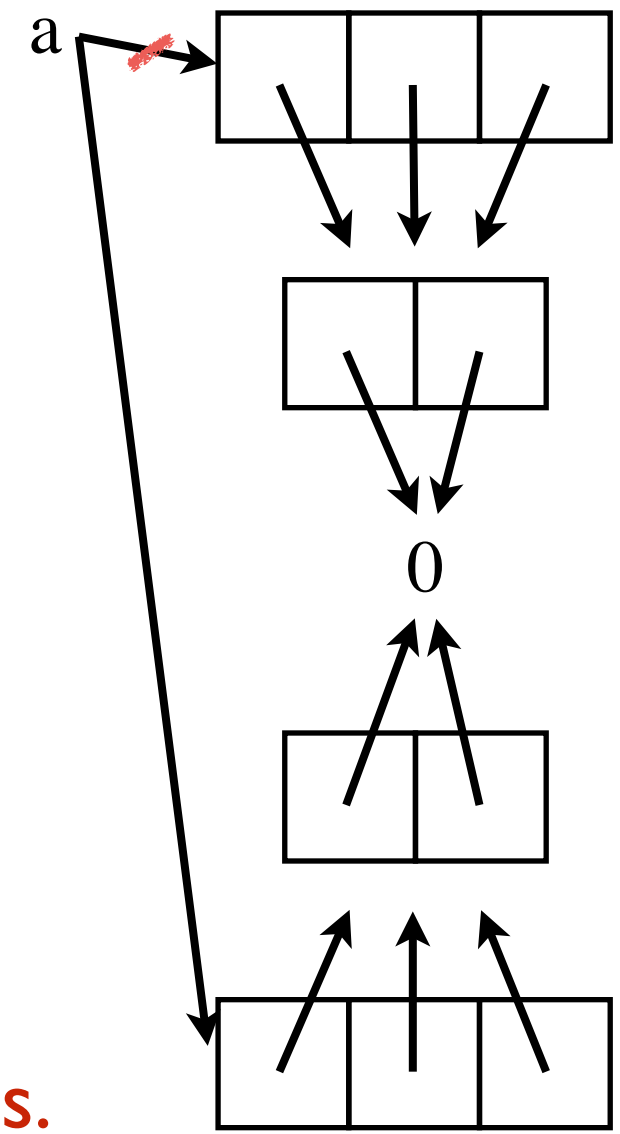
```
# Create a 3 by 2 list
a = [ [0]*2 ]*3
```

Trying to break aliasing with deepcopy:

```
a = copy.deepcopy(a)
```

deepcopy preserves alias structure!

see myDeepCopy in the notes.



Rules

A list operation or function that makes a copy
(e.g. +, list slicing, sorted function) makes a shallow copy.

* operation creates aliases.
Don't use it to create 2d lists.

Never use copy with 2d lists.

- creates aliases
- ok to use with 1d lists since elements are immutable.

Remember: deepcopy does not break alias structure within the list.

3d Lists

```
a1 = [ [ 1, 2 ],
       [ 3, 4 ] ]

a2 = [ [ 5, 6, 7 ],
       [ 8, 9 ]    ]

a3 = [ [ 10 ] ]
```

3d list:

```
a = [ a1, a2, a3 ]
```

4d list:

```
a = [ a, a ]
```

3d Lists

```
a = [   [ [ 1, 2 ],
          [ 3, 4 ] ],
                    [ [ 5, 6, 7 ],
                      [ 8, 9 ] ],
                                  [ [ 10 ] ]
    ]
```

Printing elements of 3d lists:

```
for i in range(len(a)):
    for j in range(len(a[i])):
        for k in range(len(a[i][j])):
            print("a[%d][%d][%d] = %d" % (i, j, k, a[i][j][k]))
```

Example Problem: Word Search

HEATINGOIL
KEROSENE
AGAMATE
KEROULTRA
TANKER
DELIVERY
RUNOUT
TATEOIL
FILLUP
LITRES
DRIVER
FREEDOM
ACCOUNT
ORDER
CENTRALHEATING
CUSTOMERSERVICE
BOILER
PUMP
GASOIL
DIESEL
ADBLUE
ANTIWAX
LUBRICANTS
PARAFFIN
ENGINEOIL
GREASE
BUNDEDTANK
APOLLO
MONITOR
SALESTEAM

Example Problem: Word Search

```
def testWordSearch():
    board = [ [ 'd', 'o', 'g' ],
              [ 't', 'a', 'c' ],
              [ 'o', 'a', 't' ],
              [ 'u', 'r', 'k' ],
            ]
    print(wordSearch(board, "dog"))     # ('dog', (0, 0), 'right')
    print(wordSearch(board, "cat"))     # ('cat', (1, 2), 'left')
    print(wordSearch(board, "tad"))     # ('tad', (2, 2), 'up-left')
    print(wordSearch(board, "cow"))     # None
```

Example Problem: Word Search

```
def wordSearch(board, word):
    # ...
```

Algorithm: wordSearch(board, word)

- go through each **cell** of the board one by one:
    - check if word appears starting at that **cell**

Example Problem: Word Search

```
def wordSearch(board, word):
    # ...
```

Algorithm: wordSearch(board, word)

- go through each **cell** of the board one by one:
  - check if word appears starting at that **cell**

needs to be broken down further

Example Problem: Word Search

```
def wordSearchFromCell(board, word, startRow, startCol):
    # ...
```

Algorithm: wordSearchFromCell(board, word, startRow, startCol)

- go through each **direction** one by one:
    - check if word appears in that **direction** starting at the given cell

Example Problem: Word Search

```
def wordSearchFromCell(board, word, startRow, startCol):
    # ...
```

Algorithm: wordSearchFromCell(board, word, startRow, startCol)

- go through each **direction** one by one:
  - check if word appears in that **direction** starting at the given cell

needs to be broken down further

it is important how you represent **direction**.

let's see an elegant way of doing it…