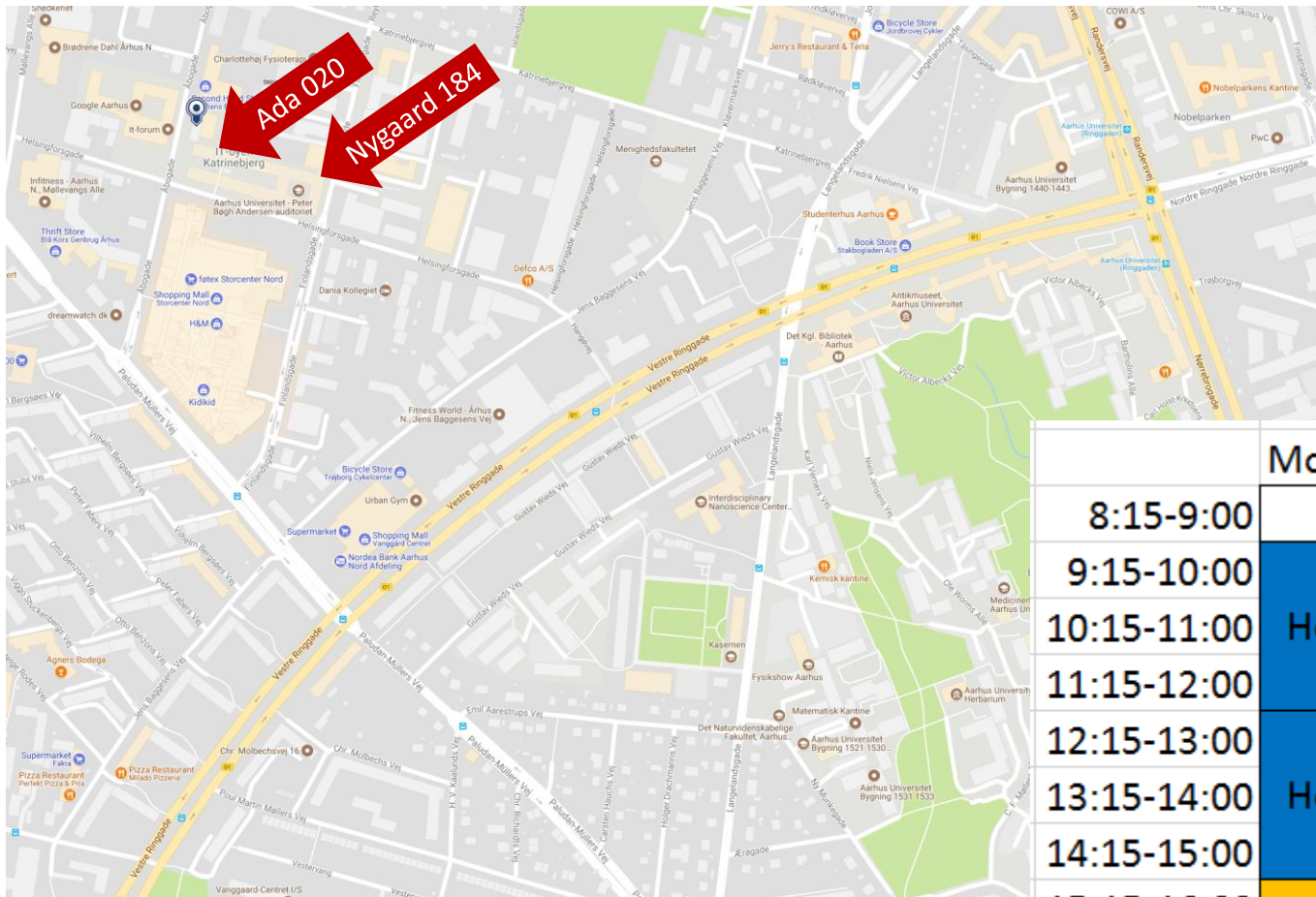


Study café hours



	Monday	Tuesday	Wednesday	Thursday	Friday
8:15-9:00					Lecture
9:15-10:00		Hold 3			
10:15-11:00	Hold 2				
11:15-12:00			Study café		
12:15-13:00					
13:15-14:00	Hold 1				
14:15-15:00			Lecture	Hold 4	
15:15-16:00					
16:15-17:00					

Lists

- List syntax
- List operations
- `copy.deepcopy`
- `range`
- `while-else`
- `for`
- `for-break-continue-else`

List operations

- List syntax `[value1, value2, ..., valuek]`
- List indexing `L[index]`, `L[-index]`
- List **slices** `L[from:to]`, `L[from:to:step]` or `L[slice(from, to, step)]`
- Creating a copy of a list `L[:]` or `L.copy()`
- List concatenation (creates new list) `X + Y`
- List repetition (repeated concatenation with itself) `42 * L`
- Length of list `len(L)`
- Check if element is in list `e in L`
- Index of first occurrence of element in list `L.index(e)`
- Number of occurrences of element in list `L.count(e)`
- Check if element is not in list `e not in L`
- `sum(L)` `min(L)` `max(L)`

List modifiers (lists are mutable)


- Extend list with elements (X is modified) `X.extend(Y)`
- Append an element to a list (L is modified) `L.append(42)`
- Replace sublist by another list (length can differ) `X[i:j] = Y`
- Delete elements from list `del L[i:j:k]`
- Remove & return element at position `L.pop(i)`
- Remove first occurrence of element `L.remove(e)`
- Reverse lists `L.reverse()`
- `L *= 42`
- `L.insert(i, x)` same as `L[i:i]=x`

Python shell

```
> x = [1, 2, 3, 4, 5]
> x[2:4] = [10, 11, 12]
> x
| [1, 2, 10, 11, 12, 5]
> x = [1, 2, 11, 5, 8]
> x[1:4:2] = ['a', 'b']
| [1, 'a', 11, 'b', 8]
```

Questions – What is `x` ?


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

- a) [1, 2, 'a', 'b', 5, 6, 7, 8, 9, 10]
- b) [1, 'a', 3, 4, 5, 6, 7, 'b', 9, 10]
- c) [1, 2, 3, 4, 5, 6, 7, 'a', 'b']
-  d) [1, 2, 'a', 4, 5, 'b', 7, 8, 9, 10]
- e) ValueError
- f) Don't know

Questions – What is `y` ?

```
y = [1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19]
```

```
y = y[3:15:3][1:4:2]
```

- a) [3, 6, 9, 12, 15]
-  b) [7, 13]
- c) [1, 9]
- d) [4, 7, 10, 13, 2, 4]
- e) TypeError
- f) Don't know

Nested lists (multi-dimensional lists)

- Lists can contain lists as elements, that can contain lists as elements, that ...
- Can e.g. be used to store multi-dimensional data (list lengths can be non-uniform)

Note: For dealing with matrices the numpy module is a better choice

```
multidimensional-lists.py
```

```
list1d = [1, 3, 5, 2]
list2d = [[1, 2, 3, 4],
          [5, 6, 7, 9],
          [0, 8, 2, 3]]
list3d = [[[5,6], [4,2], [1,7], [2,4]],
          [[1,2], [6,3], [2,5], [7,5]],
          [[3,8], [1,5], [4,3], [2,4]]]

print(list1d[2])
print(list2d[1][2])
print(list3d[2][0][1])
```

```
Python shell
```

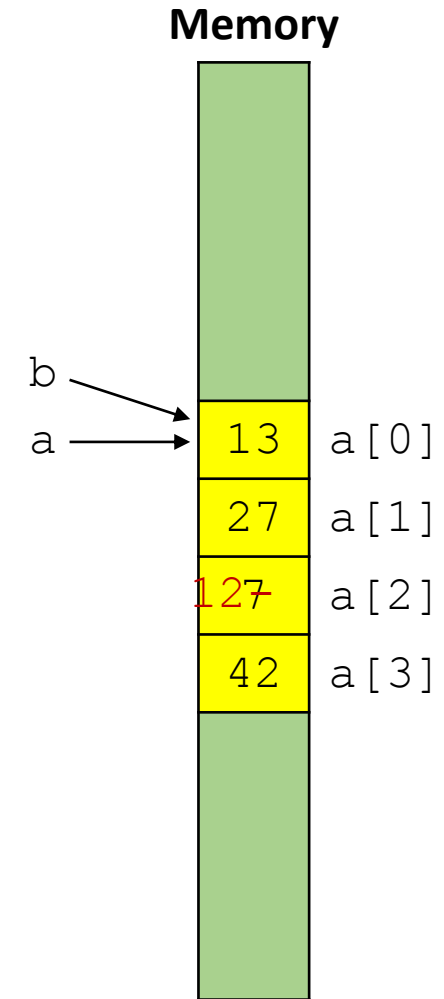
```
| 5
| 7
| 8
```

aliasing

```
a = [13, 27, 7, 42]
```

```
b = a
```

```
a[2] = 12
```

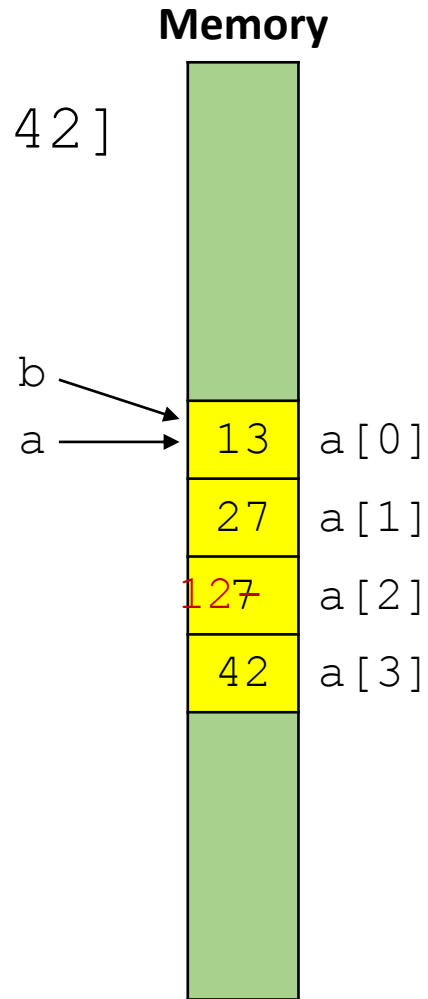


$y = x$ VS $y = x[:]$

`a = [13, 27, 7, 42]`

`b = a`

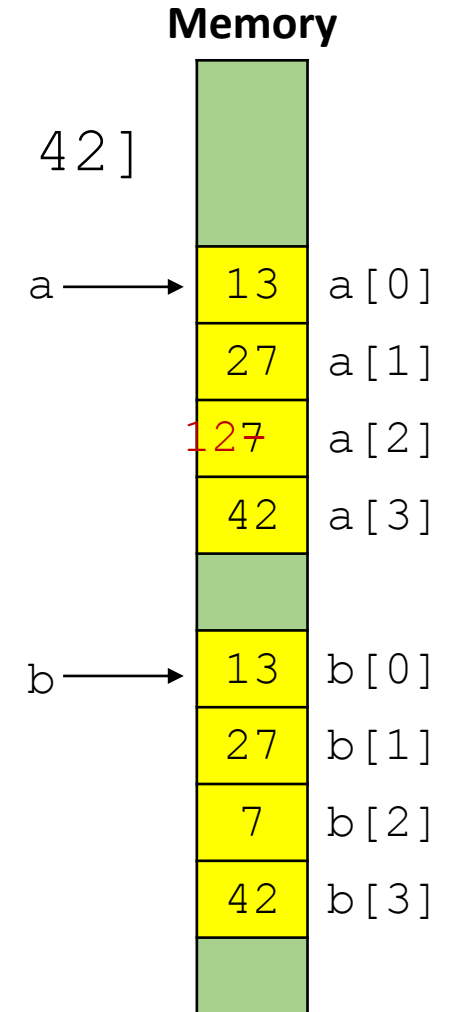
`a[2] = 12`



`a = [13, 27, 7, 42]`

`b = a[:]`

`a[2] = 12`



⊗ [:] vs nested structures

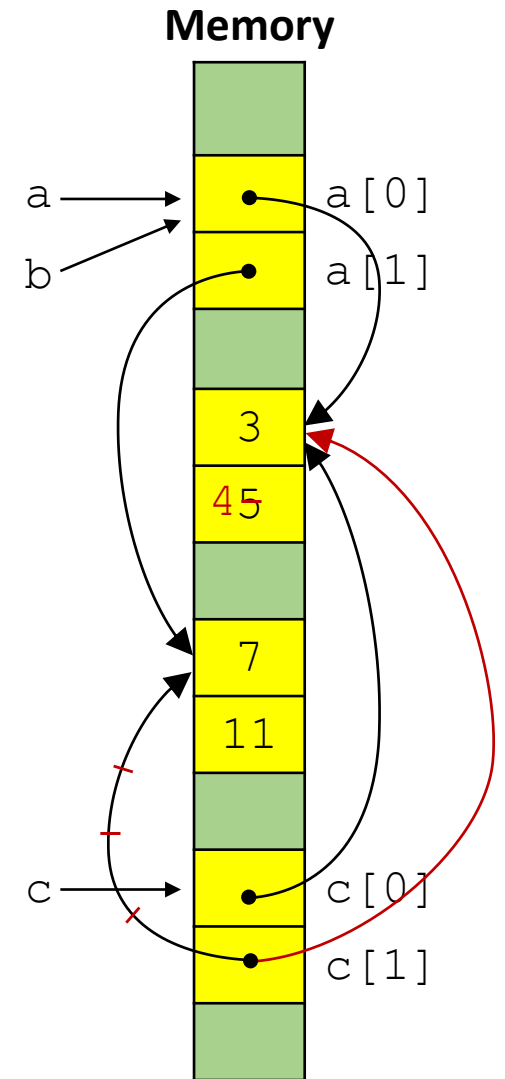
```
a = [[3, 5], [7, 11]]
```

```
b = a
```

```
c = a[:]
```

```
a[0][1] = 4
```

```
c[1] = b[0]
```



Question – what is c ?

- a) `[[3, 5], [7, 11]]`
- b) `[[3, 5], [3, 5]]`
- c) `[[3, 4], [3, 5]]`
- 😊 d) `[[3, 4], [3, 4]]`
- e) Don't know

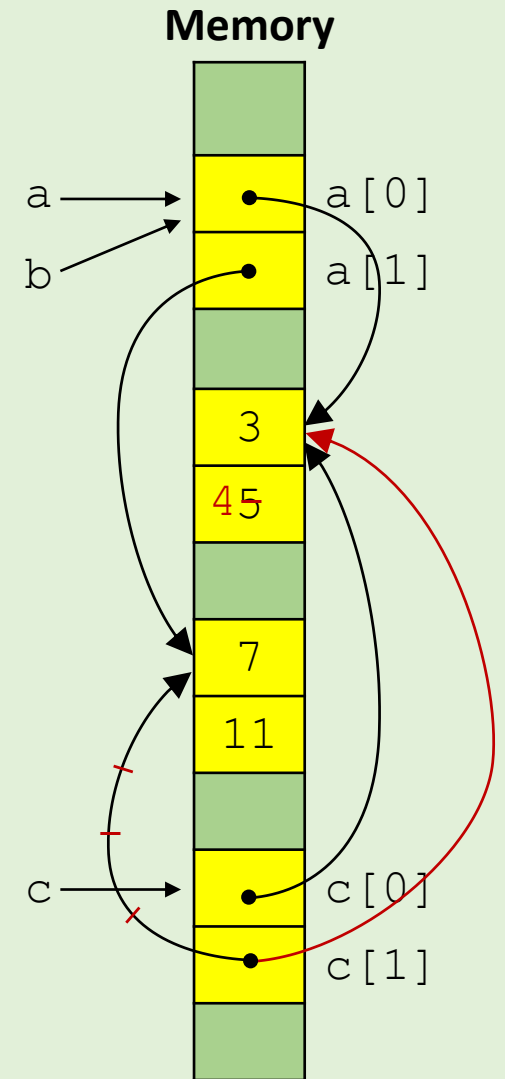
`a = [[3, 5], [7, 11]]`

`b = a`

`c = a[:]`

`a[0][1] = 4`

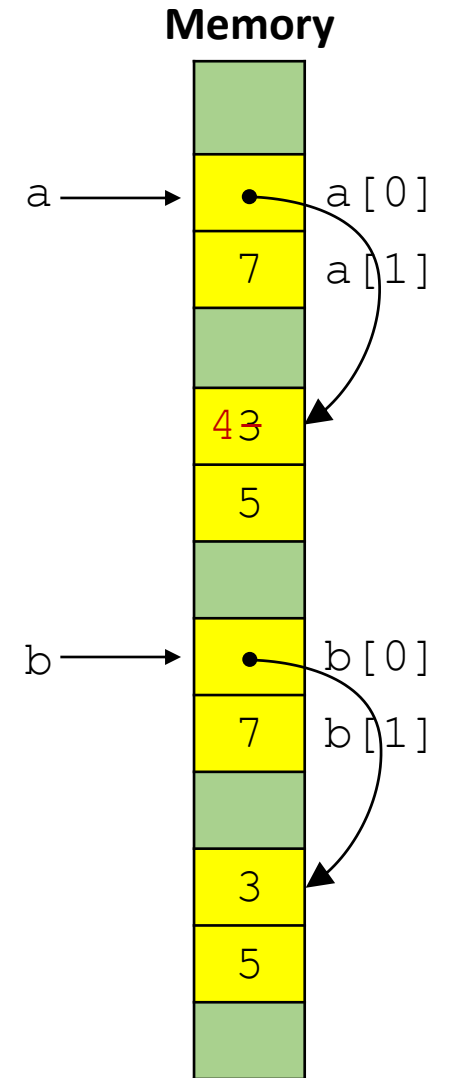
`c[1] = b[0]`



copy.deepcopy

- To make a copy of all parts of a composite value use the function `deepcopy` from module `copy`

```
Python shell
> from copy import deepcopy
> a = [[3, 5], 7]
> b = deepcopy(a)
> a[0][0] = 4
> a
| [[4, 5], 7]
> b
| [[3, 5], 7]
```



Initializing a 2-dimensional list



Python shell

```
> x = [1] * 3
> x
| [1, 1, 1]
> y = [[1] * 3] * 4
> y
| [[1, 1, 1], [1, 1, 1], [1, 1, 1], [1, 1, 1]]
> y[0][0] = 0
> y
| [[0, 1, 1], [0, 1, 1], [0, 1, 1], [0, 1, 1]]
```

Python shell

```
> y = []
> for _ in range(4): y.append([1] * 3)
> y[0][0] = 0
> y
| [[0, 1, 1], [1, 1, 1], [1, 1, 1], [1, 1, 1]]
```

range(*from*, *to*, *step*)

- range (*from*, *to*, *else*) generates a **sequence** of numbers smaller than *to* starting with *from*, and with increments of *step*:

```
range(5)           : 0, 1, 2, 3, 4
```

```
range(3, 8)        : 3, 4, 5, 6, 7
```

```
range(2, 11, 3)    : 2, 5, 8
```

- Ranges are immutable, can be indexed like a list, sliced, and compared (i.e. generate the same numbers)
- list(range(...)) generates the explicit list of numbers

Python shell


```
> range(1, 10000000, 3) [2]
| 7
> range(1, 10000000, 3) [100:120:4]
| range(301, 361, 12)
> range(1, 10000000, 3) [100:120:4] [2:3]
| range(325, 337, 12)
> list(range(5, 14, 3))
| [5, 8, 11]
```

Question – What is `range(3, 20, 4)[2:4][1]` ?

a) 3

b) 7

c) 11

 d) 15

e) 19

f) Don't know

for - loop

- For every element in a **sequence** execute a block of code:

```
for var in sequence:  
    block
```

- Sequences can e.g. be lists, strings, ranges
- `break` and `continue` can be used like in a while-loop to break out of the for-loop or continue with the next element in the sequence

Python shell


```
> for x in [1, "abc", [2, 3], 5.0]:  
>     print(x)  
| 1  
| abc  
| [2, 3]  
| 5.0  
> for x in "abc":  
>     print(x)  
| a  
| b  
| c  
> for x in range(5, 15, 3):  
>     print(x)  
| 5  
| 8  
| 11  
| 14
```


Question – What is printed ?

Python shell

```
> for i in range(1, 4):  
>     for j in range(i, 4):  
>         print(i, j, sep=':', end=' ')
```

a) 1:1 1:2 1:3 2:1 2:2 2:3 3:1 3:2 3:3

 b) 1:1 1:2 1:3 2:2 2:3 3:3

c) 1:1 2:1 3:1 1:2 2:2 3:2 1:3 2:3 3:3

d) 1:1 2:1 3:1 2:2 3:2 3:3

e) Don't know

*** COMMODORE 64 BASIC V2 ***

64K RAM SYSTEM 38911 BASIC BYTES FREE

```
READY.  
10 FOR I=1 TO 10  
20 PRINT I  
30 NEXT I  
RUN
```

1
2
3
4
5
6
7
8
9
10

READY.
█

***** COMMODORE 64 BASIC V2 *****

64K RAM SYSTEM 38911 BASIC BYTES FREE

```
READY.  
10 FOR I=1 TO 3  
20   FOR J=I TO 3  
30     PRINT I, J  
40   NEXT J  
50 NEXT I  
RUN  
1  
1  
1  
2  
2  
3  
3
```

READY.

Palindromic substrings

- Find all **palindromic** substrings of length ≥ 2 , that are spelled identically forward and backwards:

abracadrabratrallalla

i j i j

- Algorithm:** Test all possible substrings (brute force/exhaustive search)
- Note:** the slice `t[::-1]` is `t` reversed

palindrom.py

```
s = "abracadrabratrallalla"

for i in range(len(s)):
    for j in range(i + 2, len(s) + 1):
        t = s[i:j]
        if t == t[::-1]:
            print(t)
```

Python shell

```
| aca
| alla
| allalla
| ll
| lla11
| la1
| alla
| ll
```

Sieve of Eratosthenes

- Find all prime numbers $\leq n$
- Algorithm:

② 3 4 5 6 7 8 9 10 11 12 13 14 ...
2 ③ 4 5 6 7 8 9 10 11 12 13 14 ...
2 3 4 ⑤ 6 7 8 9 10 11 12 13 14 ...
2 3 4 5 6 ⑦ 8 9 10 11 12 13 14 ...
2 3 4 5 6 7 8 9 10 ⑪ 12 13 14 ...
2 3 4 5 6 7 8 9 10 11 12 ⑬ 14 ...

eratosthenes.py

```
n = 100
prime = [True] * (n + 1)

for i in range(2, n):
    for j in range(2 * i, n + 1, i):
        prime[j] = False

for i in range(2, n+1):
    if prime[i]:
        print(i, end=' ')
```

Python shell

```
| 2 3 5 7 11 13 17 19 23 29 31 37 41
  43 47 53 59 61 67 71 73 79 83 89
  97
```

while-else and for-else loops

- Both for- and while-loops can have an optional “else”:

```
for var in sequence:
```

```
    block
```

```
else:
```

```
    block
```

```
while condition:
```

```
    block
```

```
else:
```

```
    block
```

- The “else” block is only executed if no `break` is performed in the loop
- The “else” construction for loops is specific to Python, and does not exist in e.g. C, C++ and Java

Linear search

linear-search-while.py

```
L = [7, 3, 6, 4, 12, 'a', 8, 13]
x = 4

i = 0
while i < len(L):
    if L[i] == x:
        print(x, "at position", i, "in", L)
        break
    i = i + 1

if i >= len(L):
    print(x, "not in", L)
```

linear-search-while-else.py

```
i = 0
while i < len(L):
    if L[i] == x:
        print(x, "at position", i, "in", L)
        break
    i = i + 1
else:
    print(x, "not in", L)
```

linear-search-for.py

```
found = False
for i in range(len(L)):
    if L[i] == x:
        print(x, "at position", i, "in", L)
        found = True
        break

if not found:
    print(x, "not in", L)
```

linear-search-for-else.py

```
for i in range(len(L)):
    if L[i] == x:
        print(x, "at position", i, "in", L)
        break
else:
    print(x, "not in", L)
```

linear-search-builtin.py

```
if x in L:
    print(x, "at position", L.index(x), "in", L)
else:
    print(x, "not in", L)
```