CS1010S

Tutorial 7: List Processing

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List Processing

Key Concepts

Lists

Lists

~~Im~~mutable sequences

Tuples vs Lists

Tuple sequences

- (), (1,) and (2,3)
- Immutable
- Can be used as **dict** keys

```
tup = (1,2,3)
tup[0] == 1 # True
tup[0] = 4  # TypeError

print(tup)  # (1,2,3)
```

List sequences

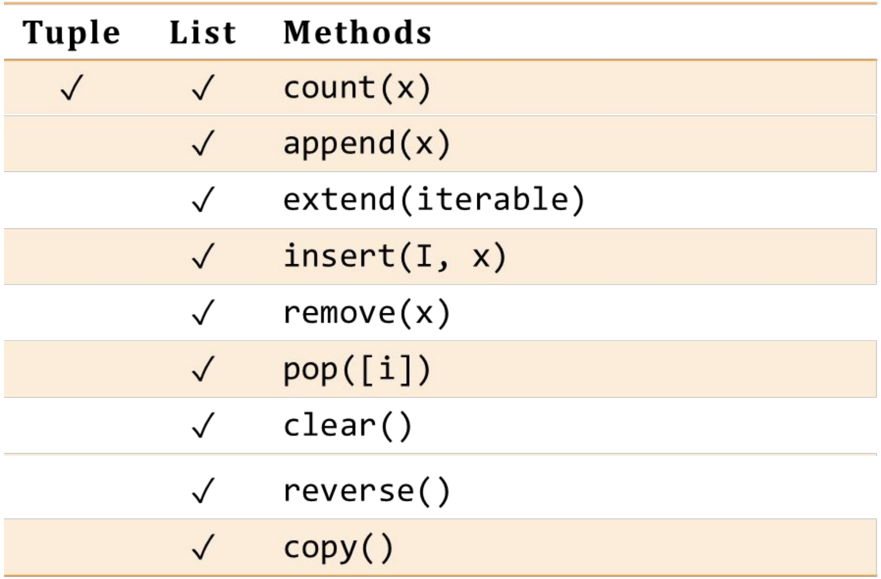
- [], [1] and [2,3]
- Mutable
- Cannot be used as **dict** keys

```
lst = [1,2,3]
lst[0] == 1 # True
lst[0] = 4

print(lst)  # [4,2,3]
```

List Methods

https://docs.python.org/3/tutorial/datastructures.html



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lst = [1,2,3,2]
lst.count(2)
lst.count(4)
```

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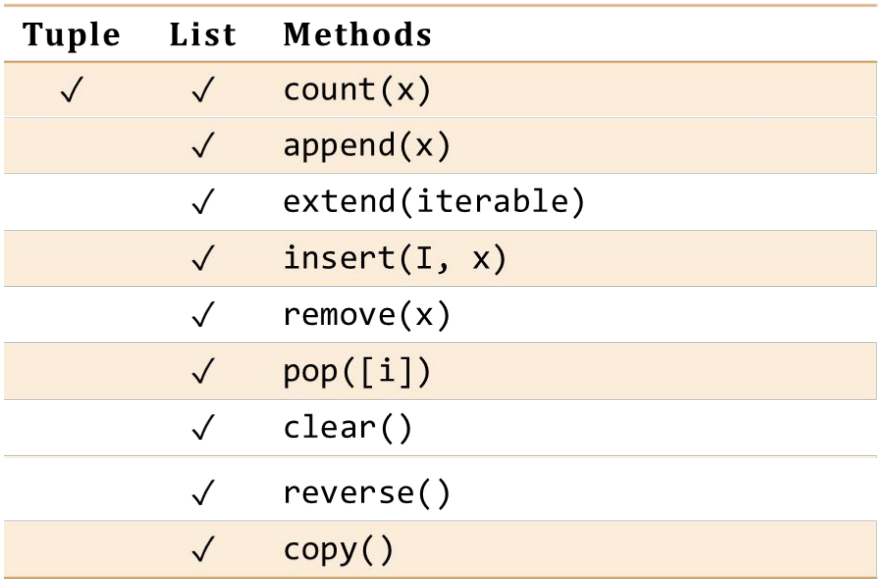

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List Methods

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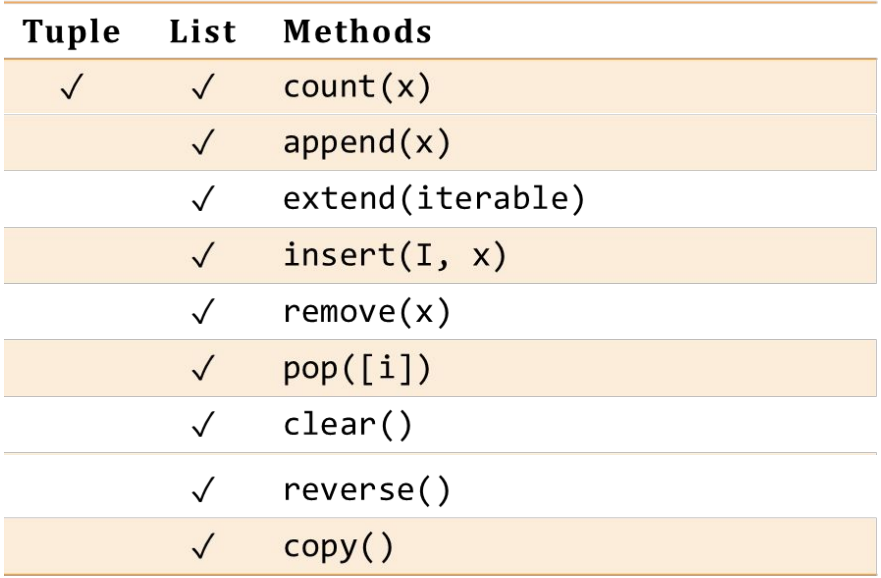

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```
lst = [1,2,3,2]
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lst.count(4) # 0
```

List Methods

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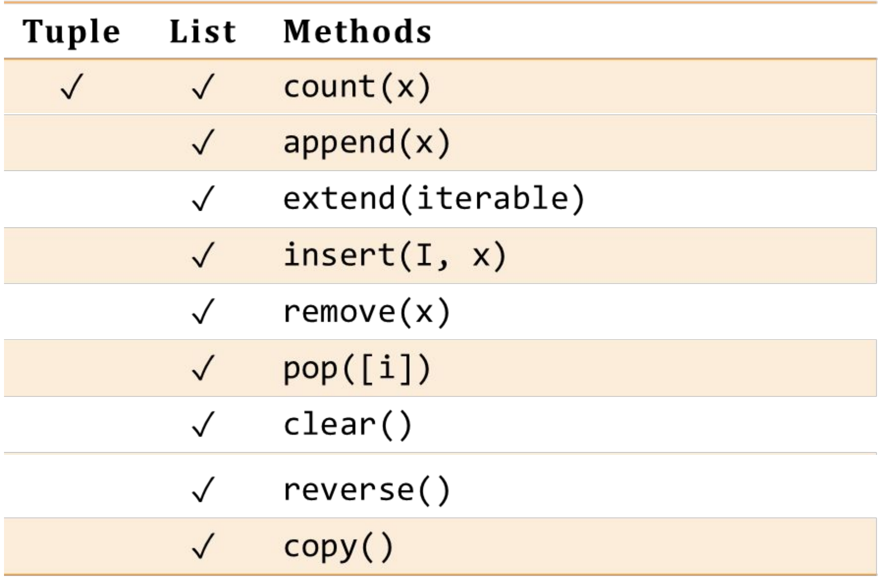

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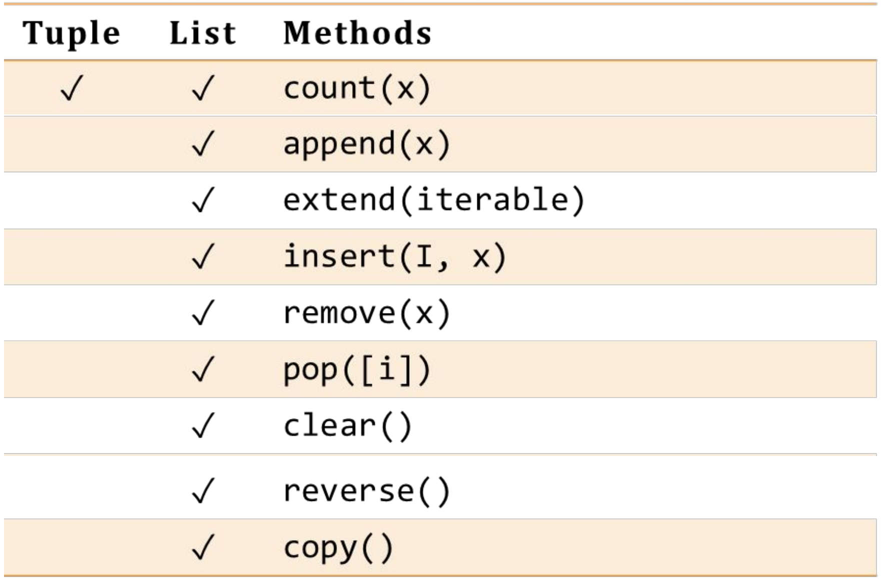

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```
lst = [1,2,3,2]
lst.count(2)  # 2
lst.count(4)  # 0

lst.reverse()
lst
lst.append(4)
lst.remove(2)
lst
```

List Methods

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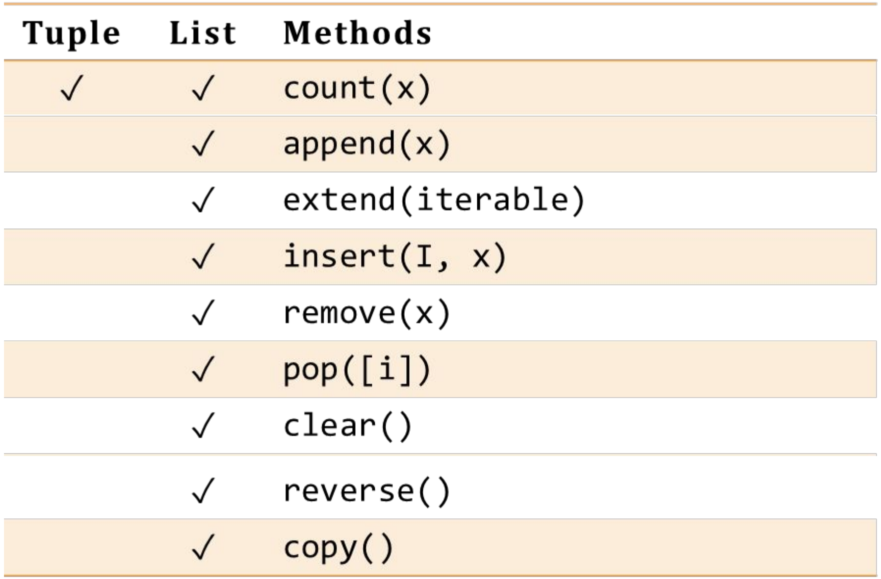

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```
lst = [1,2,3,2]
lst.count(2) # 2
lst.count(4) # 0

lst.reverse()
lst # [2,3,2,1]
lst.append(4)
lst.remove(2)
lst
```

List Methods

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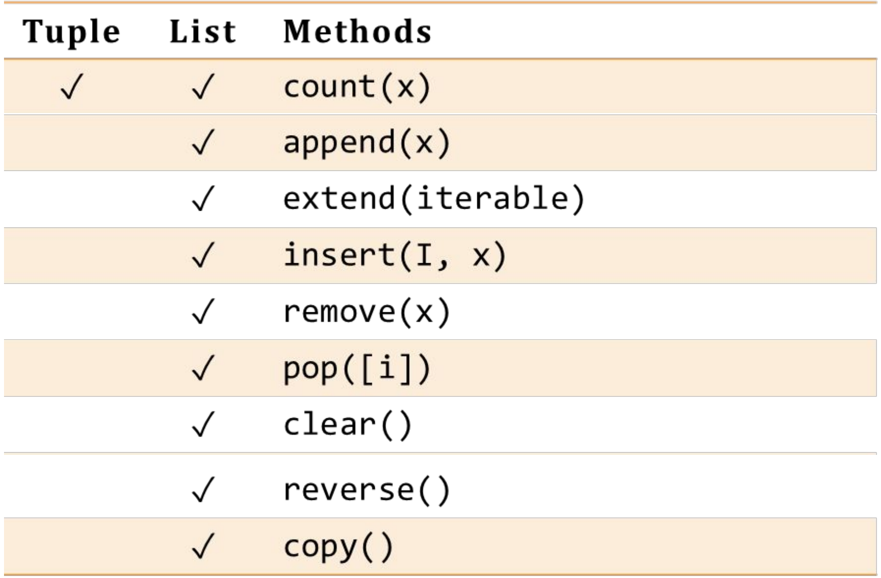

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```

List Methods

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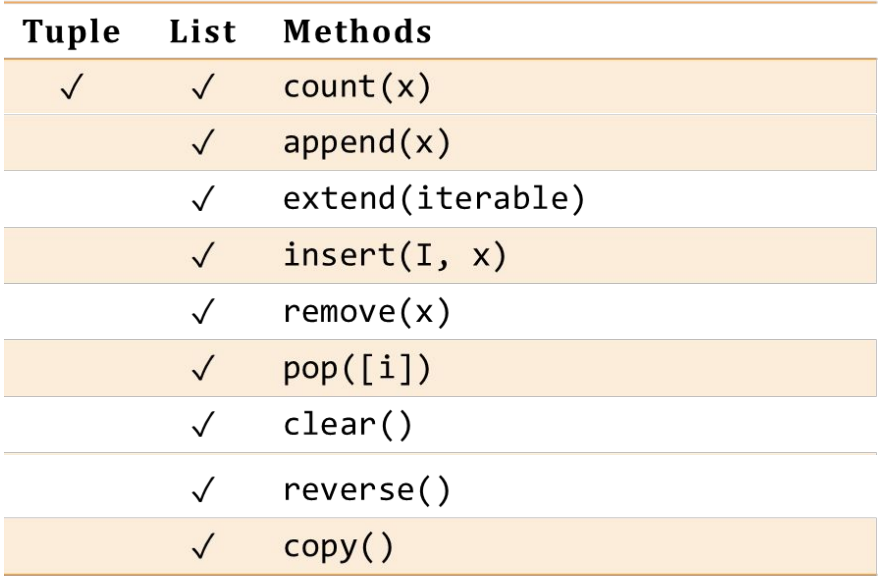

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lst.count(2) # 2
lst.count(4) # 0

lst.reverse()
lst # [2,3,2,1]
lst.append(4)
lst.remove(2)
lst # [3,2,1,4]

lst = sorted(lst)
lst
lst.pop()
lst
```

List Methods

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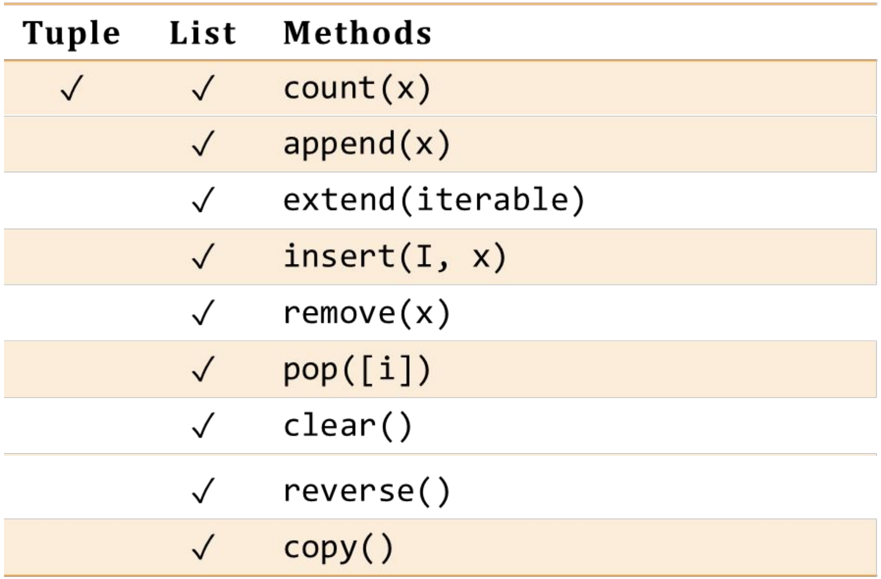

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lst # [2,3,2,1]
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lst = sorted(lst)
lst # [1,2,3,4]
lst.pop()
lst
```

List Methods

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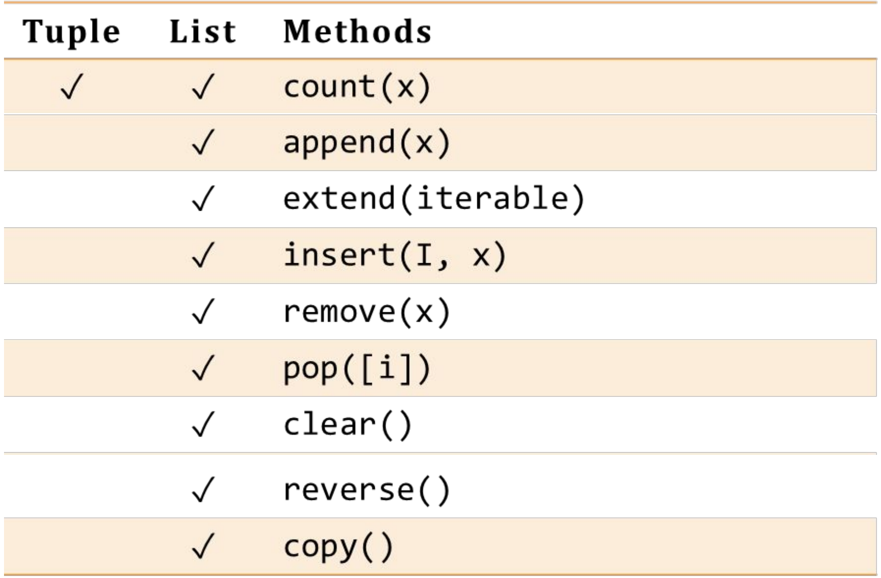

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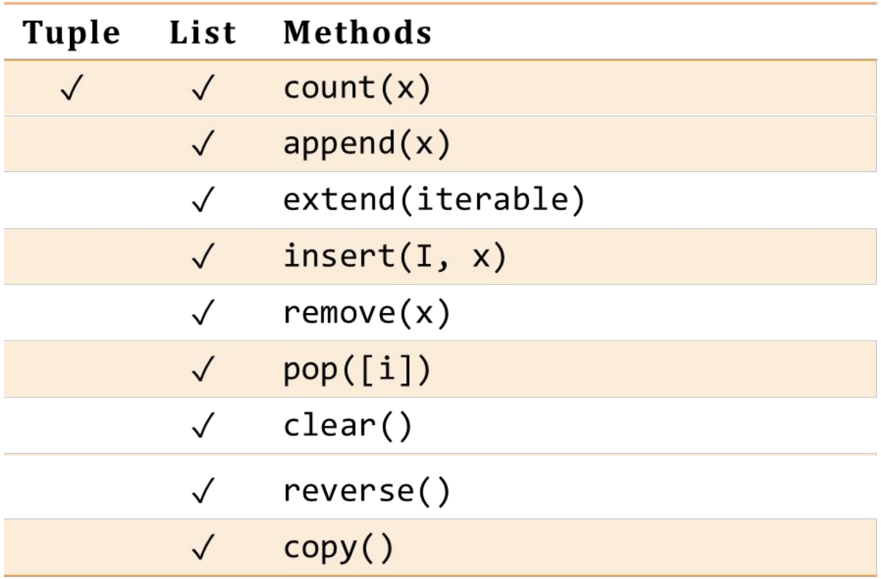
```
lst = [1,2,3,2]
lst.count(2)  # 2
lst.count(4)  # 0

lst.reverse()
lst # [2,3,2,1]
lst.append(4)
lst.remove(2)
lst # [3,2,1,4]

lst = sorted(lst)
lst # [1,2,3,4]
lst.pop()  # 4
lst
```

List Methods

https://docs.python.org/3/tutorial/datastructures.html



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```
lst = [1,2,3,2]
lst.count(2) # 2
lst.count(4) # 0

lst.reverse()
lst # [2,3,2,1]
lst.append(4)
lst.remove(2)
lst # [3,2,1,4]

lst = sorted(lst)
lst # [1,2,3,4]
lst.pop() # 4
lst # [1,2,3]
```

Operations and more

```
# lists are mutable
lst = [0]
lst[0] = lst
print(lst[0][0][0] == lst)
print(lst)
```

Operations and more

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# lists are mutable
lst = [0]
lst[0] = lst
print(lst[0][0][0] == lst) # True
print(lst)
```

Operations and more

```python
# lists are mutable
lst = [0]
lst[0] = lst
print(lst[0][0][0] == lst) # True
print(lst) # [[...]]
```

List operations are in-place

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

# Concatenation
print(lst + [4, 5])
print(lst)

# lst.extend(iterable)
print(lst.extend([4,5]))
print(lst)

# lst.append(element)
print(lst.append(6))
print(lst)
```

List operations are in-place

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

# Concatenation
print(lst + [4, 5])      # [1, 2, 3, 4, 5]
print(lst)               # [1, 2, 3]

# lst.extend(iterable)
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List operations are in-place

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

# Concatenation
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print(lst)               # [1, 2, 3]

# lst.extend(iterable)
print(lst.extend([4,5])) # None
print(lst)               # [1, 2, 3, 4, 5]

# lst.append(element)
print(lst.append(6))
print(lst)
```

List operations are in-place

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lst = [1, 2, 3]

# Concatenation
print(lst + [4, 5])      # [1, 2, 3, 4, 5]
print(lst)               # [1, 2, 3]

# lst.extend(iterable)
print(lst.extend([4,5])) # None
print(lst)               # [1, 2, 3, 4, 5]

# lst.append(element)
print(lst.append(6))     # None
print(lst)               # [1, 2, 3, 4, 5, 6]
```

Box-pointer diagram

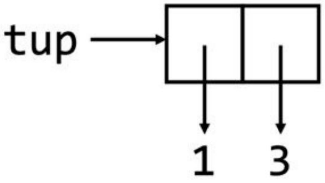
EXTREMELY USEFUL TOOL TO MODEL REFERENCE TYPE OBJECT

```
1.   x = [[1]]
     y = (x[0], x)

2.   x[0] += [y]
     y[1].append(2)

3.   y += (3,)
     y[1][0] = y[0][0]
     print(y is y[0][1])
     print(x[0] in y)
```

Box-pointer diagram

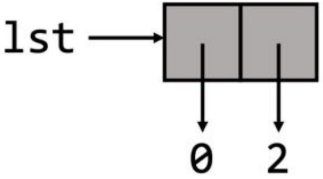
- Recap: `tuple` visualization

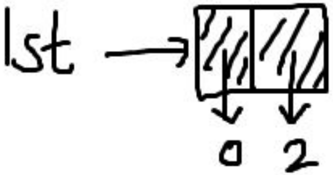
```
>>> tup = (1, 3)
```



- `list` visualization is similar
  - Gray boxes to indicate mutability

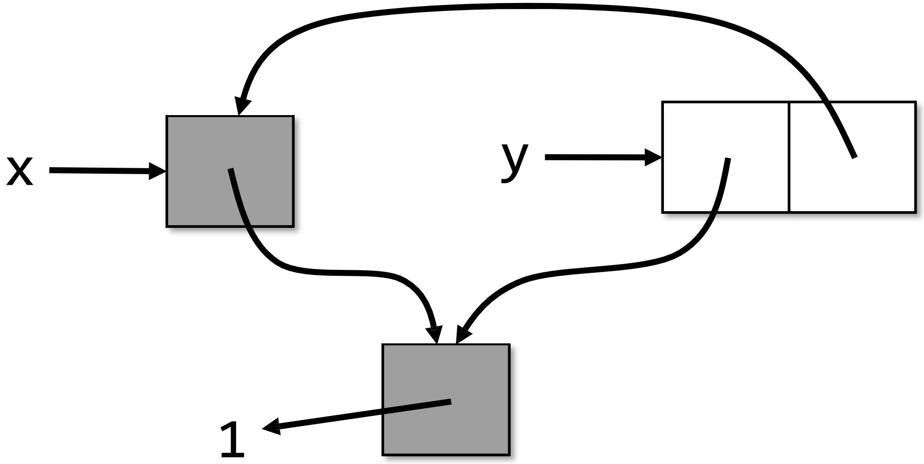
```
>>> lst = [0, 2]
>>> lst[0] = 5
```





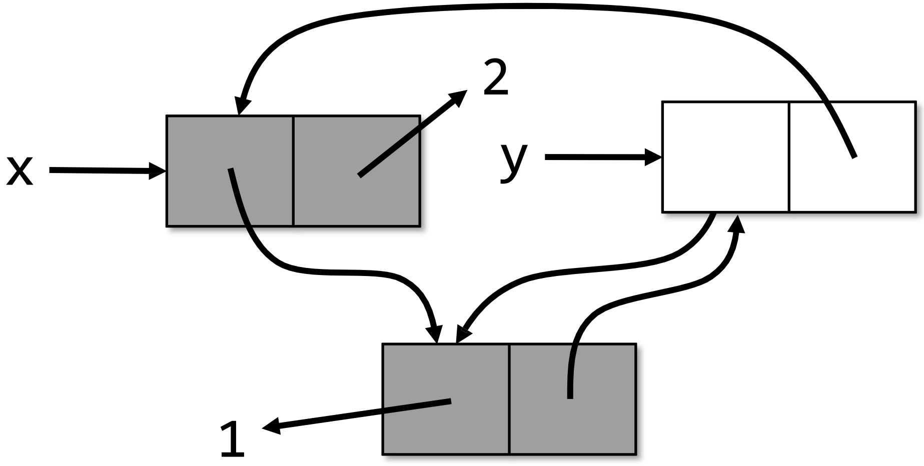
Box-pointer diagram

```
1.   x = [[1]]
     y = (x[0], x)
```



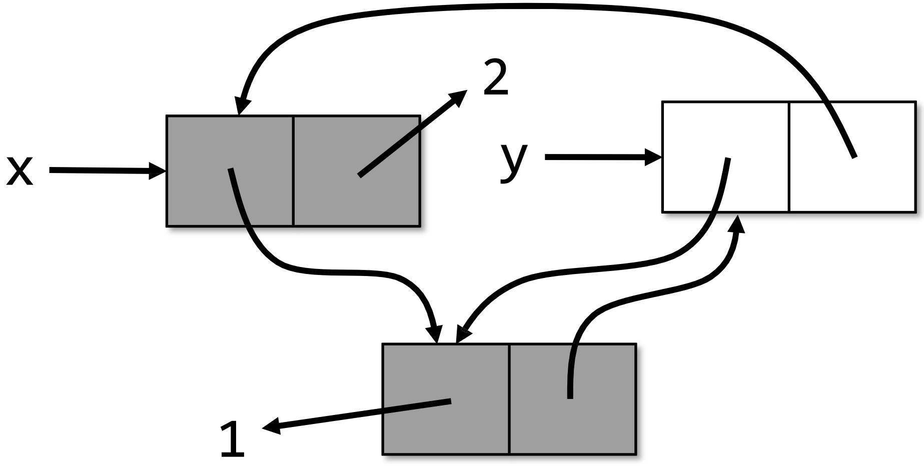
Box-pointer diagram

```
2.   x[0] += [y]
     y[1].append(2)
     print(y is y[0][1]) # True/False?
     print(x[0] in y) # True/False?
```



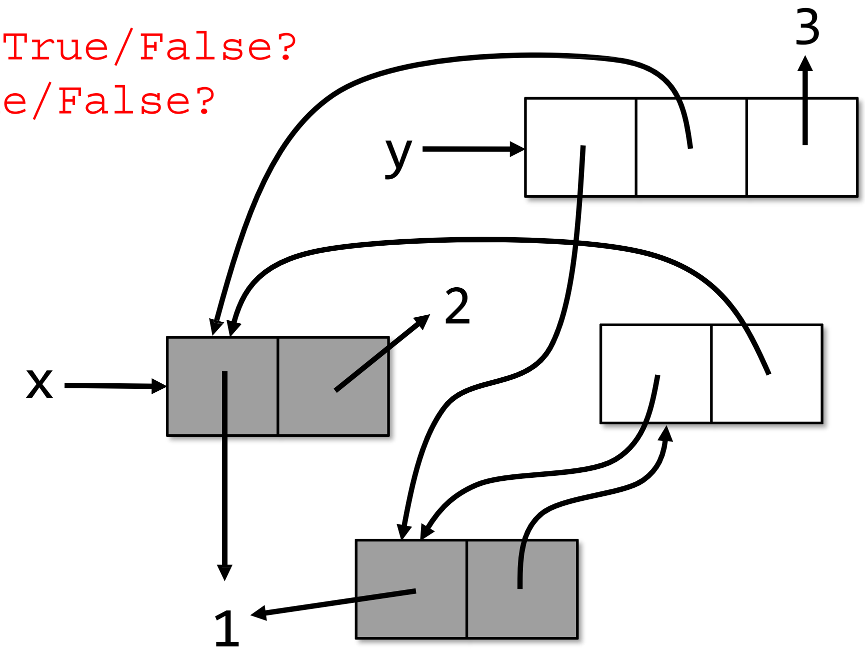
Box-pointer diagram

```
2.   x[0] += [y]
     y[1].append(2)
     print(y is y[0][1]) # True
     print(x[0] in y) # True
```



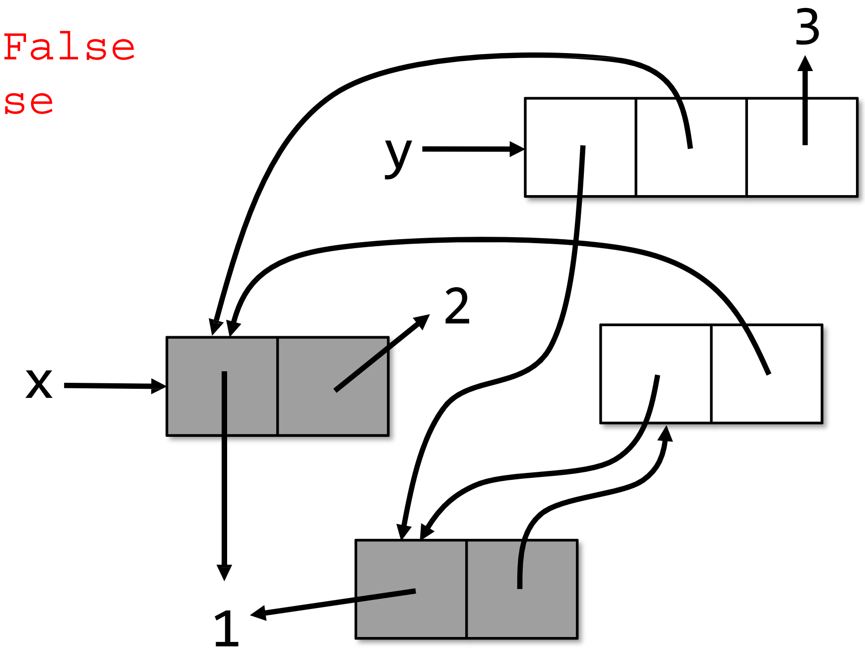
Box-pointer diagram

```
3.  y += (3,) # since y is a tuple
    y[1][0] = y[0][0]
    print(y is y[0][1]) # True/False?
    print(x[0] in y) # True/False?
```



Box-pointer diagram

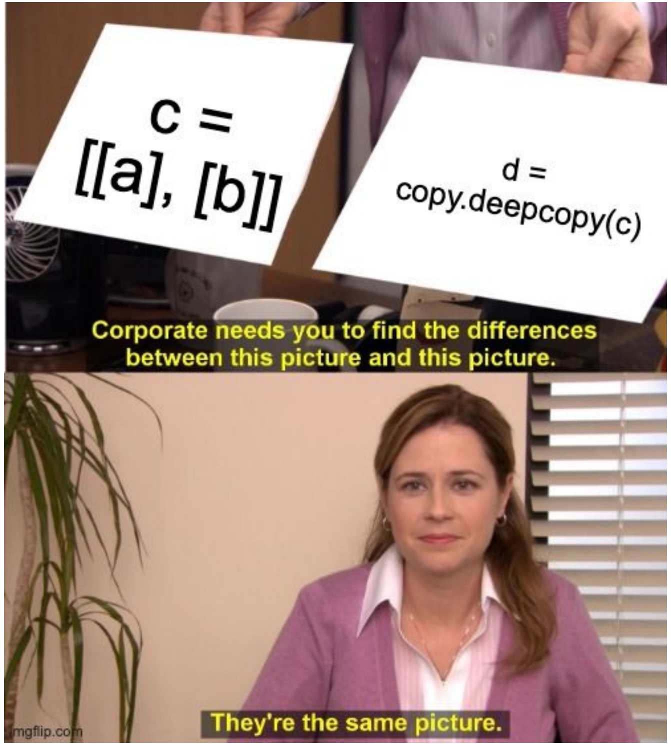
```
3.  y += (3,) # since y is a tuple
    y[1][0] = y[0][0]
    print(y is y[0][1]) # False
    print(x[0] in y) # False
```



Time to copy

Shallow Copy vs Deep Copy

- Why do we need to deep copy?

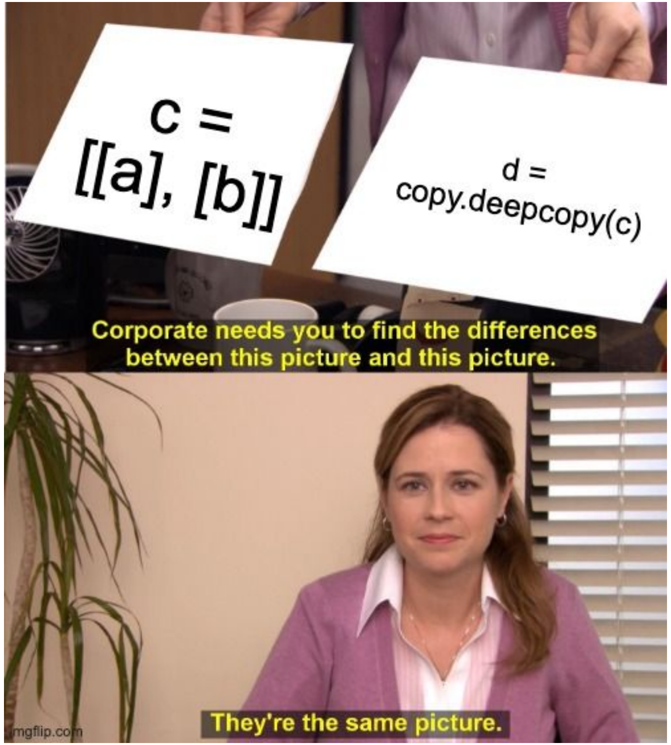


c = [[a], [b]]
d = copy.deepcopy(c)
Corporate needs you to find the differences between this picture and this picture.
They're the same picture.
imgflip.com

Time to copy

Shallow Copy

```
>>> a = [[1,2]]
>>> b = a.copy()
>>> a[0] is b[0]
    True
```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[[a], [b]]
d =
copy.deepcopy(c)
Corporate needs you to find the differences
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Time to copy

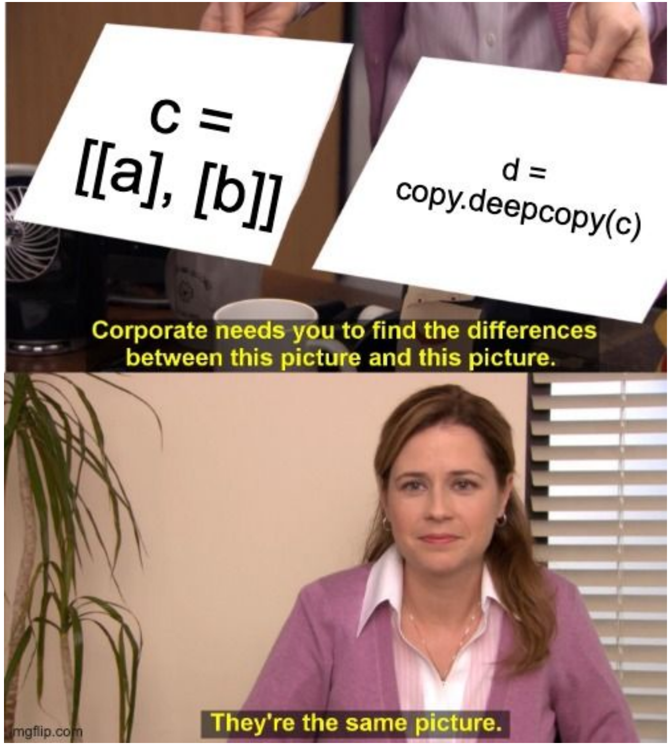
```
Deep Copy

from copy import deepcopy

>>> a = [[1,2]]
>>> b = deepcopy(a)
>>> a[0] is b[0]
    False



# YOU ARE NOT ALLOWED TO USE
# ANY LIBRARY IN CS1010S
# (unless explicitly allowed)
```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Tutorial 7

List Processing

Question 1: At Least N

Ben Bitdiddle is required to implement a function **at_least_n** which takes in **a list of integers** and an integer **n**, and returns the **original** list with all the integers smaller than n removed.

```
>>> lst = list(range(0,10,1))
>>> lst2 = at_least_n(lst, 5)
>>> lst2
    [5, 6, 7, 8, 9]
>>> lst is lst2
    True
```

Question 1a: At Least N

```python
def at_least_n(lst, n):
    for i in range(0,len(lst),1):
        if lst[i] < n:
            lst.remove(lst[i])
    return lst

at_least_n(list(range(0,7,1)), 5)
```

What’s wrong with this implementation?

Question 1a: At Least N

```
def at_least_n(lst, n):
    for i in range(0,len(lst),1):
        if lst[i] < n:
            lst.remove(lst[i])
    return lst

at_least_n(list(range(0,7,1)), 5) # IndexError
```

What’s wrong with this implementation?

```
# IndexError, size of list decreases
```

Question 1b: At Least N

```
def at_least_n(lst, n):
    for i in lst:
        if i < n:
            lst.remove(i)
    return lst

at_least_n(list(range(0,7,1)), 5)
```

What’s wrong with this implementation?

Question 1b: At Least N

```
def at_least_n(lst, n):
    for i in lst:
        if i < n:
            lst.remove(i)
    return lst

at_least_n(list(range(0,7,1)), 5) # [1, 3, 5, 6]

What’s wrong with this implementation?

# Index preserved across iterations
```

Click here for python tutor

Question 1c: At Least N

```
def at_least_n(lst, n):
    for i in list(lst):
        if i < n:
            lst.remove(i)
    return lst

at_least_n(list(range(0,7,1)), 5)
```

Question 1c: At Least N

```
def at_least_n(lst, n):
    for i in list(lst):
        if i < n:
            lst.remove(i)
    return lst

at_least_n(list(range(0,7,1)), 5) # [5, 6]

# In-place, iterate over list copy
```

Question 1c: At Least N

```
def at_least_n(lst, n):
    for i in reversed(range(0,len(lst),1)):
        if lst[i] < n:
           lst.pop(i)
    return lst

at_least_n(list(range(0,7,1)), 5)
```

Question 1c: At Least N

```
def at_least_n(lst, n):
    for i in reversed(range(0,len(lst),1)):
        if lst[i] < n:
            lst.pop(i)
    return lst

at_least_n(list(range(0,7,1)), 5)

# In-place, iterate from rear of list
# reversed(range(0, 10, 1)) ≡ range(9, -1, -1)
```

Question 1c++: At Least N

```
def at_least_n(lst, n):
    i = len(lst) - 1
    while i >= 0:
        if lst[i] < n:
            lst.pop(i)
        i -= 1
    return lst

at_least_n(list(range(0, 7, 1)), 5)
```

Question 1c++: At Least N

```
def at_least_n(lst, n):
    i = len(lst) - 1
    while i >= 0:
        if lst[i] < n:
            lst.pop(i)
        i -= 1
    return lst

at_least_n(list(range(0, 7, 1)), 5)

# In-place, iterate from rear of list
```

Question 1d: At Least N

```python
def at_least_n(lst, n):
    return list(filter(lambda x: x>=n, lst))


# New list is created

lst = list(range(0,10,1))
lst2 = at_least_n(lst , 5)
lst is lst2 # False
```

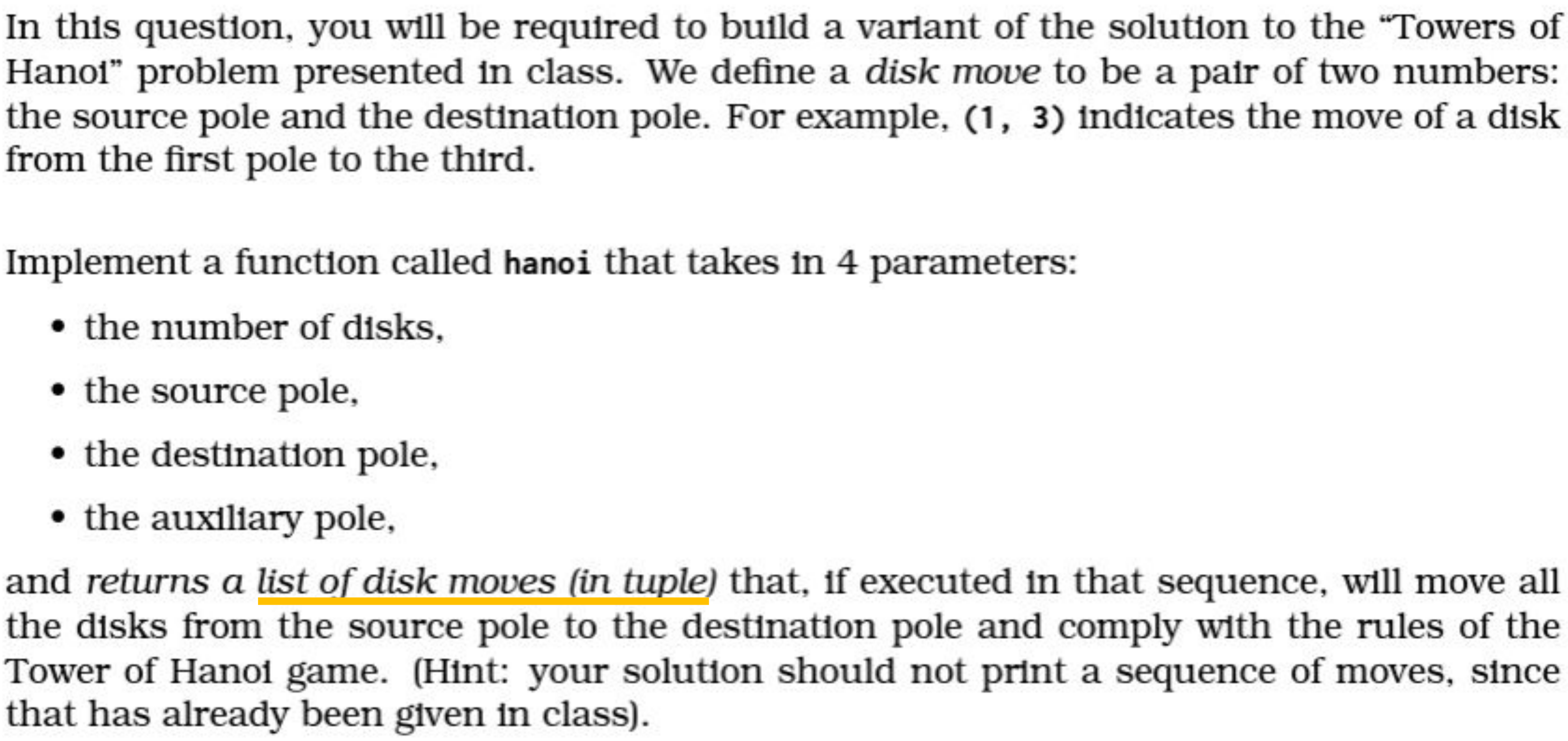
Question 1d: At Least N

```
def at_least_n(lst, n):
    new_lst = []
    for i in lst:
        if i >= n:
            new_lst.append(i)
    return new_lst

# New list is created

lst = list(range(0,10,1))
lst2 = at_least_n(lst , 5)
lst is lst2 # False
```

Question 2: Hanoi



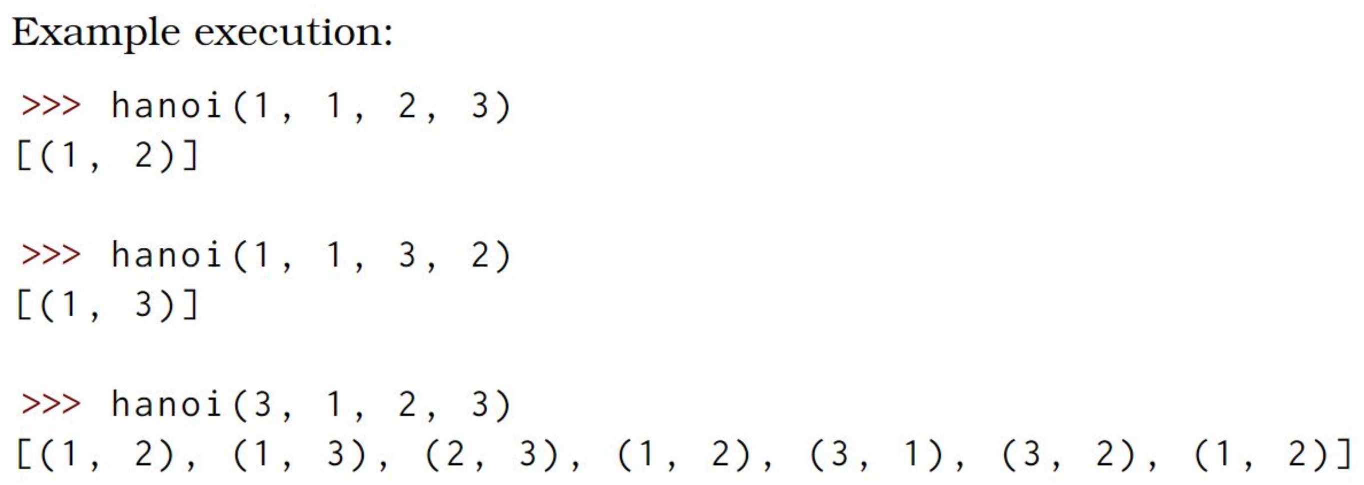
In this question, you will be required to build a variant of the solution to the "Towers of Hanoi" problem presented in class. We define a *disk move* to be a pair of two numbers: the source pole and the destination pole. For example, `(1, 3)` indicates the move of a disk from the first pole to the third.

Implement a function called **`hanoi`** that takes in 4 parameters:

- the number of disks,
- the source pole,
- the destination pole,
- the auxiliary pole,

and *returns a list of disk moves (in tuple)* that, if executed in that sequence, will move all the disks from the source pole to the destination pole and comply with the rules of the Tower of Hanoi game. (Hint: your solution should not print a sequence of moves, since that has already been given in class).

Question 2: Hanoi



Example execution:

```
>>> hanoi(1, 1, 2, 3)
[(1, 2)]

>>> hanoi(1, 1, 3, 2)
[(1, 3)]

>>> hanoi(3, 1, 2, 3)
[(1, 2), (1, 3), (2, 3), (1, 2), (3, 1), (3, 2), (1, 2)]
```

Question 2: Hanoi tuples (printing)

```
def hanoi(n, src, dsc, aux):
    if n == 0:
        return
    hanoi(n-1, src, aux, dsc) # Move n-1 to aux
    print(f"{src} -> {dsc}")  # Move nth to dsc
    hanoi(n-1, aux, dsc, src) # Move n-1 to dsc

>>> hanoi(2, 1, 2, 3)
```

Question 2: Hanoi tuples (printing)

```
def hanoi(n, src, dsc, aux):
    if n == 0:
        return
    hanoi(n-1, src, aux, dsc) # Move n-1 to aux
    print(f"{src} -> {dsc}")  # Move nth to dsc
    hanoi(n-1, aux, dsc, src) # Move n-1 to dsc

>>> hanoi(2, 1, 2, 3)
    1 -> 3
    1 -> 2
    3 -> 2
```

Question 2: Hanoi tuples (returning)

```python
def hanoi(n, src, dsc, aux):
    if n == 0:
        return []
    else:
        return hanoi(n-1, src, aux, dsc)   # Concatenation
           + [(src, dsc),]
           + hanoi(n-1, aux, dsc, src)

>>> hanoi(2, 1, 2, 3) # [(1, 3)] + [(1, 2)] + [(3, 2)]
    [(1, 3), (1, 2), (3, 2)]
```

Extra Questions

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

Extra Questions

```
a = [1, 2]

a += [a]

print(a)

b = a.copy() # shallow copy vs deep copy

a[2] = 0

print(a)

print(b)
```

The End