Programming Principles in Python (CSCI 503)

Sequences

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Functions

- `def <function-name>(<parameter-names>):`
  `    # do stuff`
  `    return res`
- Use `return` to return a value
- Can return more than one value using commas
- `def <function-name>(<parameter-names>):`
  `    # do stuff`
  `    return res1, res2`
- Use **simultaneous assignment** when calling:
  - `a, b = do_something(1,2,5)`
- If there is no return value, the function returns `None` (a special value)

Scope

- The **scope** of a variable refers to where in a program it can be referenced
- Python has three scopes:
  - **global**: defined outside a function
  - **local**: in a function, only valid in the function
  - **nonlocal**: can be used with nested functions
- Python allows variables in different scopes to have the **same name**

Local Scope

- ```
  def f(): # no arguments
      x = 2
      print("x in function:", x)

  x = 1
  f()
  print("x in main:", x)
  ```
- Output:
  - ```
    x in function: 2
    x in main: 1
    ```
- Here, the `x` in `f` is in the local scope

Global Keyword for Global Scope

- ```
  def f(): # no arguments
      global x
      x = 2
      print("x in function:", x)

  x = 1
  f()
  print("x in main:", x)
  ```
- Output:

```
- x in function: 2
  x in main: 2
```

- Here, the `x` in `f` is in the global scope because of the global declaration
```

Python as Pass-by-Value?

- ```
  def change_list(inner_list):
      inner_list = [10,9,8,7,6]

  outer_list = [0,1,2,3,4]
  change_list(outer_list)
  outer_list # [0,1,2,3,4]
  ```

- Looks like pass by value!
  ```

Python as Pass-by-Reference?

- ```
  def change_list(inner_list):
      inner_list.append(5)

  outer_list = [0,1,2,3,4]
  change_list(outer_list)
  outer_list # [0,1,2,3,4,5]
  ```

- Looks like pass by reference!
  ```

Python is Pass-by-object-reference

- AKA passing object references by value
- Python doesn't allocate space for a variable, it just links identifier to a value
- **Mutability** of the object determines whether other references see the change
- Any immutable object will act like pass by value
- Any mutable object acts like pass by reference unless it is reassigned to a new value

Default Parameter Values

- Can add `=<value>` to parameters
- ```
  def rectangle_area(width=30, height=20):
      return width * height
  ```
- All of these work:
  - `rectangle_area() # 600`
  - `rectangle_area(10) # 200`
  - `rectangle_area(10,50) # 500`
- If the user does not pass an argument for that parameter, the parameter is set to the default value
- Cannot add non-default parameters after a defaulted parameter
  - ~~`def rectangle_area(width=30, height)`~~

[Deitel & Deitel]
  ```

Keyword Arguments

- Keyword arguments allow someone calling a function to specify exactly which values they wish to specify without specifying all the values
- This helps with long parameter lists where the caller wants to only change a few arguments from the defaults
- ```
  def f(alpha=3, beta=4, gamma=1, delta=7, epsilon=8, zeta=2,
        eta=0.3, theta=0.5, iota=0.24, kappa=0.134):
      # …
  ```
- ```
  f(beta=12, iota=0.7)
  ```

Assignment 2

- Due Tonight
- Python control flow and functions
- Do not use containers like lists!
- The 7x+-1 function
- Make sure to follow instructions
  - Name the submitted file a2.ipynb
  - Put your name and z-id in the first cell
  - Label each part of the assignment using markdown
  - Make sure to produce output according to specifications

Assignment 3

- Coming soon…

Sequences

- Strings are sequences of characters: "abcde"
- Lists are also sequences: [1, 2, 3, 4, 5]
- + Tuples: (1, 2, 3, 4, 5)

Lists

- Defining a list: `my_list = [0, 1, 2, 3, 4]`
- But lists can store different types:
  - `my_list = [0, "a", 1.34]`
- Including other lists:
  - `my_list = [0, "a", 1.34, [1, 2, 3]]`

~~Lists~~ Tuples

- Defining a tuple: `my_tuple = (0, 1, 2, 3, 4)`
- But tuples can store different types:
  - `my_tuple = (0, "a", 1.34)`
- Including other tuples:
  - `my_tuple = (0, "a", 1.34, (1, 2, 3))`
- How do you define a tuple with **one** element?

~~Lists~~ Tuples

- Defining a tuple: `my_tuple = (0, 1, 2, 3, 4)`
- But tuples can store different types:
  - `my_tuple = (0, "a", 1.34)`
- Including other tuples:
  - `my_tuple = (0, "a", 1.34, (1, 2, 3))`
- How do you define a tuple with **one** element?
  - `my_tuple = (1)  # doesn't work`
  - `my_tuple = (1,) # add trailing comma`

List Operations

- **Not** like vectors or matrices!
- Concatenate: `[1, 2] + [3, 4] # [1,2,3,4]`
- Repeat: `[1,2] * 3 # [1,2,1,2,1,2]`
- Length: `my_list = [1,2]; len(my_list) # 2`

~~List~~ Sequence Operations

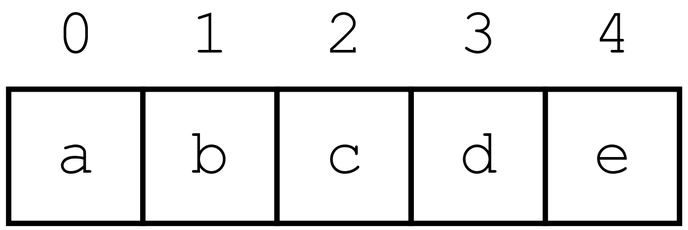
- Concatenate: `[1, 2] + [3, 4] # [1,2,3,4]`
- Repeat: `[1,2] * 3 # [1,2,1,2,1,2]`
- Length: `my_list = [1,2]; len(my_list) # 2`

- Concatenate: `(1, 2) + (3, 4) # (1,2,3,4)`
- Repeat: `(1,2) * 3 # (1,2,1,2,1,2)`
- Length: `my_tuple = (1,2); len(my_tuple) # 2`

- Concatenate: `"ab" + "cd" # "abcd"`
- Repeat: `"ab" * 3 # "ababab"`
- Length: `my_str = "ab"; len(my_str) # 2`

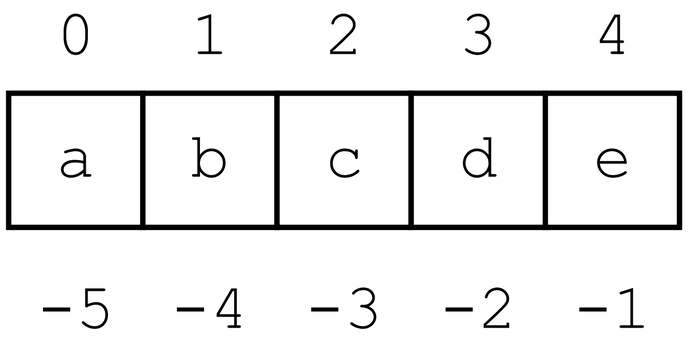
Sequence Indexing

- Square brackets are used to pull out an element of a sequence
- We always start counting at zero!
- `my_str = "abcde"; my_str[0] # "a"`
- `my_list = [1,2,3,4,5]; my_list[2] # 3`
- `my_tuple = (1,2,3,4,5); my_tuple[5] # IndexError`



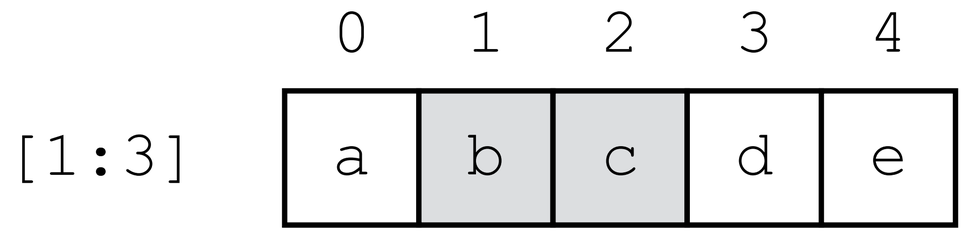
Negative Indexing

- Subtract from the end of the sequence to the beginning
- We always start counting at ~~zero~~ -1 (zero would be ambiguous!)
- `my_str = "abcde"; my_str[-1] # "e"`
- `my_list = [1,2,3,4,5]; my_list[-3] # 3`
- `my_tuple = (1,2,3,4,5); my_tuple[-5] # 1`



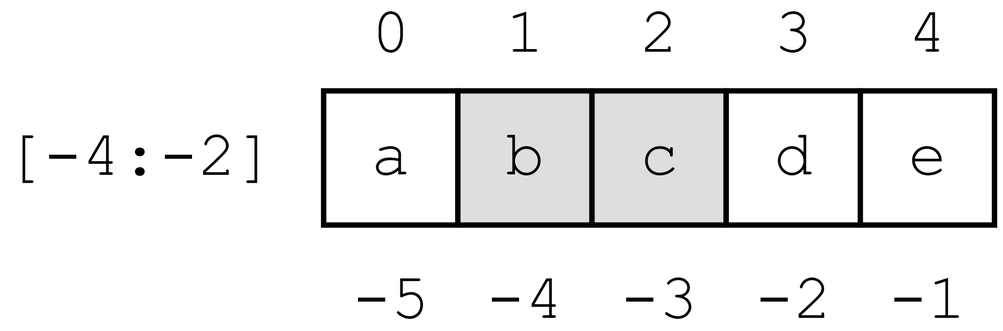
Slicing

- Want a subsequence of the given sequence
- Specify the start and the first index not included
- Returns the same type of sequence
- `my_str = "abcde"; my_str[1:3] # ["b", c"]`
- `my_list = [1,2,3,4,5]; my_list[3:4] # [4]`
- `my_tuple = (1,2,3,4,5); my_tuple[2:99] # (3,4,5)`



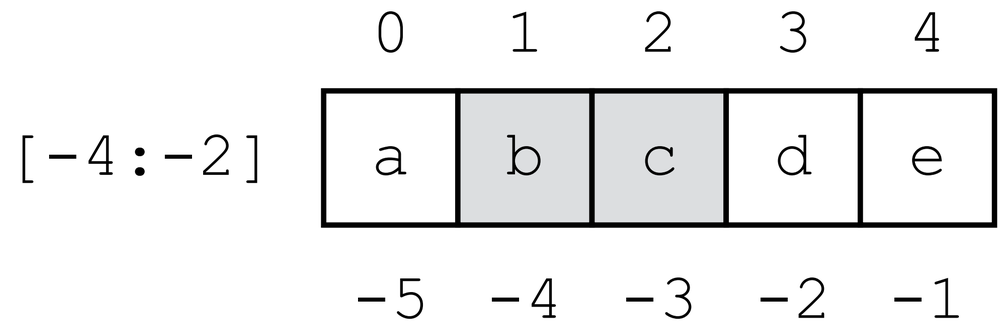
Negative Indices with Slices

- Negative indices can be used instead or with non-negative indices
- `my_str = "abcde"; my_str[-4:-2] # ["b", c"]`
- `my_list = [1,2,3,4,5]; my_list[3:-1] # [4]`
- How do we include the last element?
- `my_tuple = (1,2,3,4,5); my_tuple[-2:?]`



Negative Indices with Slices

- Negative indices can be used instead or with non-negative indices
- `my_str = "abcde"; my_str[-4:-2] # ["b", c"]`
- `my_list = [1,2,3,4,5]; my_list[3:-1] # [4]`
- How do we include the last element?
- `my_tuple = (1,2,3,4,5); my_tuple[-2:?]`

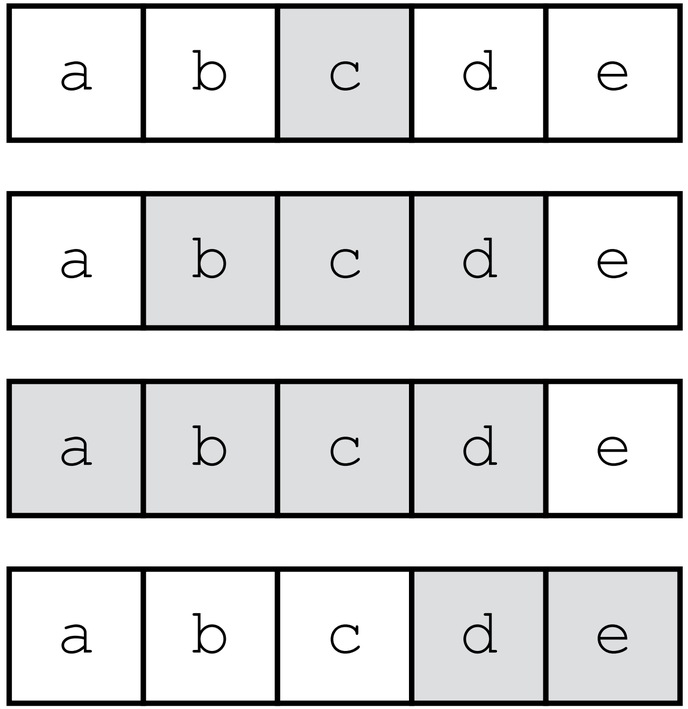


Implicit Indices

- Don't need to write indices for the beginning or end of a sequence
- Omitting the first number of a slice means start from the beginning
- Omitting the last number of a slice means go through the end
- `my_tuple = (1,2,3,4,5); ~~my_tuple[-2:len(my_tuple)]~~`
- `my_tuple = (1,2,3,4,5); my_tuple[-2:] # (4,5)`
- Can create a copy of a sequence by omitting both
- `my_list = [1,2,3,4,5]; my_list[:] # [1,2,3,4,5]`

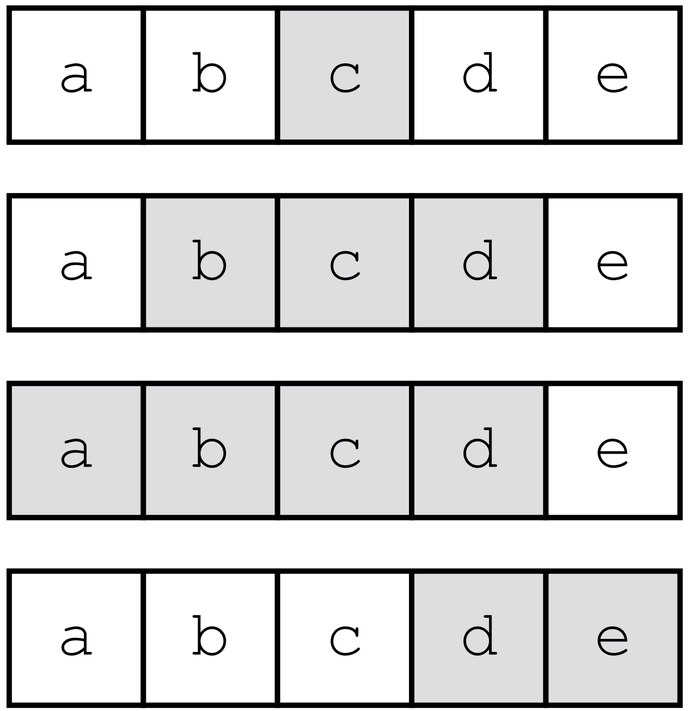
Indexing Quiz

```
my_list = ['a', 'b', 'c', 'd', 'e']
```



Indexing Quiz

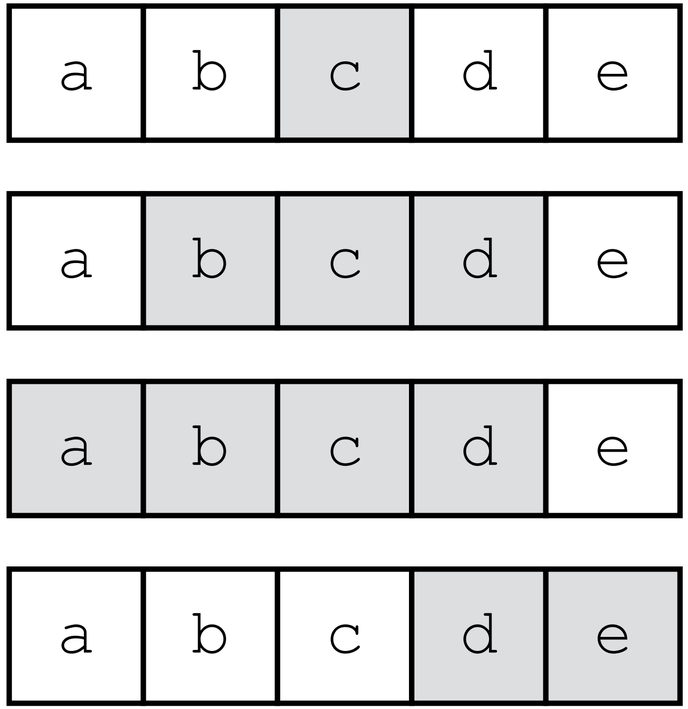
```
my_list = ['a', 'b', 'c', 'd', 'e']
```




```
my_list[2]; my_list[-3]; my_list[2:3]
```

Indexing Quiz

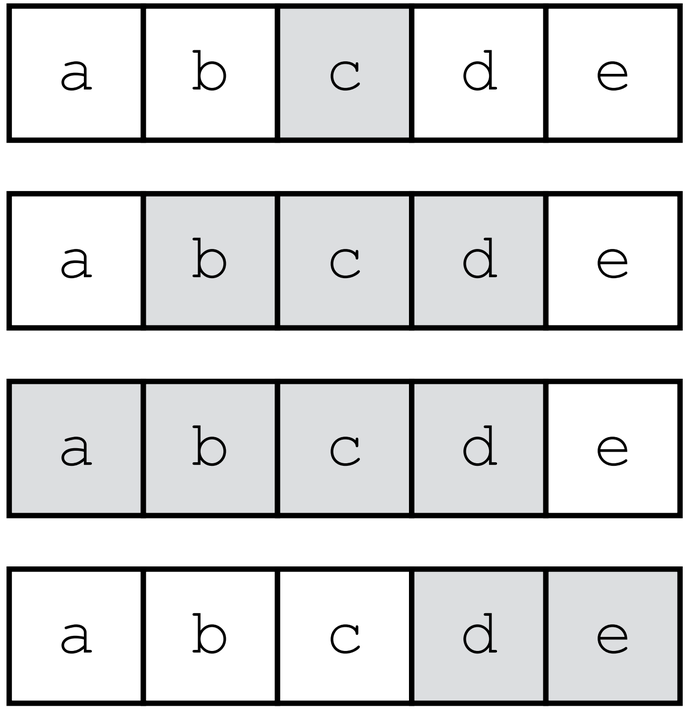
```
my_list = ['a', 'b', 'c', 'd', 'e']
```




```
my_list[2]; my_list[-3]; my_list[2:3]

my_list[1:4]; my_list[-4:-1];
my_list[1:-1]
```

Indexing Quiz

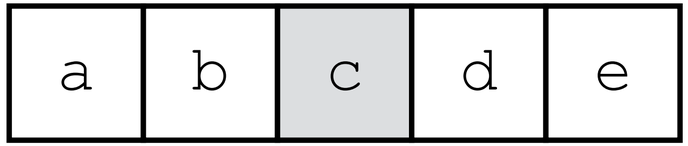
```
my_list = ['a', 'b', 'c', 'd', 'e']
```



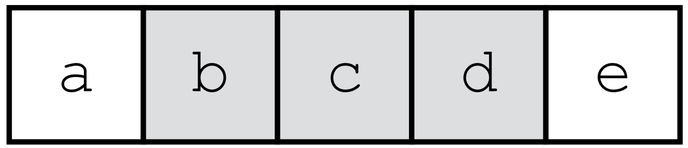

```
my_list[2]; my_list[-3]; my_list[2:3]

my_list[1:4]; my_list[-4:-1];
my_list[1:-1]

my_list[0:4]; my_list[:4];
my_list[-5:-1]
```

Indexing Quiz

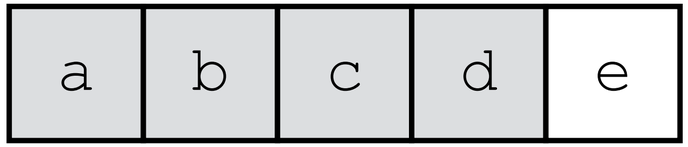
```
my_list = ['a', 'b', 'c', 'd', 'e']
```



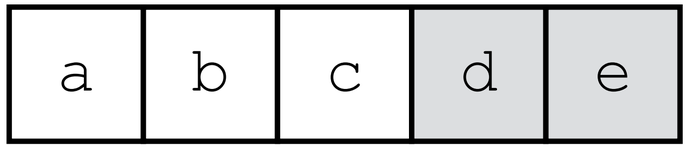

```
my_list[2]; my_list[-3]; my_list[2:3]
```




```
my_list[1:4]; my_list[-4:-1];
my_list[1:-1]
```




```
my_list[0:4]; my_list[:4];
my_list[-5:-1]
```




```
my_list[3:]; my_list[-2:]
```

Iteration

- `for d in sequence:`
  `    # do stuff`
- **Important**: `d` is a **data** item, **not** an **index**!
- `sequence = "abcdef"`
  `for d in sequence:`
  `    print(d, end=" ")  # a b c d e f`
- `sequence = [1,2,3,4,5]`
  `for d in sequence:`
  `    print(d, end=" ")  # 1 2 3 4 5`
- `sequence = (1,2,3,4,5)`
  `for d in sequence:`
  `    print(d, end=" ")  # 1 2 3 4 5`

Membership

- `<expr> in <seq>`
- Returns `True` if the expression is in the sequence, `False` otherwise
- `"a" in "abcde" # True`
- `0 in [1,2,3,4,5] # False`
- `3 in (3, 3, 3, 3) # True`

Sequence Operations

Operator	Meaning
`<seq> + <seq>`	Concatenation
`<seq> * <int-expr>`	Repetition
`<seq>[<int-expr>]`	Indexing
`len(<seq>)`	Length
`<seq>[<int-expr?>:<int-expr?>]`	Slicing
`for <var> in <seq>:`	Iteration
`<expr> in <seq>`	Membership (Boolean)

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`<seq>[<int-expr>]`	Indexing
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`<seq>[<int-expr?>:<int-expr?>]`	Slicing
`for <var> in <seq>:`	Iteration
`<expr> in <seq>`	Membership (Boolean)

`<int-expr?>`: may be `<int-expr>` but also can be empty

What's the difference between the sequences?

- Strings can only store characters, lists & tuples can store arbitrary values
- Mutability: strings and tuples are **immutable**, lists are **mutable**
- ```
  my_list = [1, 2, 3, 4]
  my_list[2] = 300
  my_list # [1, 2, 300, 4]
  ```
- `my_tuple = (1, 2, 3, 4); my_tuple[2] = 300 # TypeError`
- `my_str = "abcdef"; my_str[0] = "z" # TypeError`
  ```

List methods

Method	Meaning
`<list>.append(d)`	Add element `d` to end of list.
`<list>.extend(s)`	Add **all** elements in `s` to end of list.
`<list>.insert(i, d)`	Insert `d` into list at index i.
`<list>.pop(i)`	Deletes `i`th element of the list and returns its value.
`<list>.sort()`	Sort the list.
`<list>.reverse()`	Reverse the list.
`<list>.remove(d)`	Deletes first occurrence of `d` in list.
`<list>.index(d)`	Returns index of first occurrence of `d`.
`<list>.count(d)`	Returns the number of occurrences of `d` in list.

List methods

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`<list>.remove(d)`	Deletes first occurrence of `d` in list.	
`<list>.index(d)`	Returns index of first occurrence of `d`.	
`<list>.count(d)`	Returns the number of occurrences of `d` in list.	

The del statement

- pop works wells for removing an element by index plus it returns the element
- Can also remove an element at index i using
  - `del my_list[i]`
- Note this is very different syntax so I prefer pop
- But del can **delete slices**
  - `del my_list[i:j]`
- Also, can delete **identifier** names completely
  - ```
    a = 32
    del a
    a # NameError
    ```
- This is different than `a = None`
    ```

Updating collections

- There are three ways to deal with operations that update collections:
  - Returns an updated **copy** of the list
  - Updates the collection **in place**
  - Updates the collection in place **and returns it**
- `list.sort` and `list.reverse` work **in place** and **don't return** it
- Common error:

```
- sorted_list = my_list.sort() # sorted_list = None
```

- Instead:

```
- sorted_list = sorted(my_list)
```

sorted and reversed

- For both sort and reverse, have `sorted` & `reversed` which are **not** in place
- Called with the sequence as the argument
- ```
  my_list = [7, 3, 2, 5, 1]
  for d in sorted(my_list):
      print(d, end=" ")                    # 1 2 3 5 7
  ```
- ```
  my_list = [7, 3, 2, 5, 1]
  for d in reversed(my_list):
      print(d, end=" ")                    # 1 5 2 3 7
  ```
- But this doesn't work:
  - `reversed_list = reversed(my_list)`
- If you need a new list (same as with `range`):
  - `reversed_list = list(reversed(my_list))`

Reversed sort

- Both sort and sorted have a boolean parameter `reverse` that will sort the list in reverse
- ```
  my_list = [7, 3, 2, 5, 1]
  my_list.sort(reverse=True) # my_list now [7, 5, 3, 2, 1]
  ```
- ```
  for i in sorted(my_list, reverse=True):
      print(i, end = " ")    # prints 7 5 3 2 1
  ```
- There is also a `key` parameter that should be a **function** that will be called on each element before comparisons—the outputs will be used to sort
  - Example: convert to lowercase

Nested Sort

- By default, sorts by comparing inner elements in order
- `sorted([[4,2],[1,5],[1,3],[3,5]])`
  - 1st element:`1 == 1 < 3 < 4`
  - 2nd element for equal: `3 < 5`
  - Result: `[[1,3],[1,5],[3,5],[4,2]]`
- Longer lists after shorter lists:
  - `sorted([[1,2],[1]]) # [[1],[1,2]]`

enumerate

- Often you **do not** need the index when iterating through a sequence
- If you need an index while looping through a sequence, use `enumerate`
- ```
  for i, d in enumerate(my_list):
      print("index:", i, "element:", d)
  ```
- Each time through the loop, it yields **two** items, the **index** `i` & the **element** `d`
- `i, d` is actually a **tuple**
- Automatically **unpacked** above, can manually do this, but don't!
- ```
  for t in enumerate(my_list):
      i = t[0]
      d = t[1]
      print("index:", i, "element:", d)
  ```

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