MAT 305: Mathematical Computing

Collections

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Outline

1. Collections in Python
2. Ranges of data
3. Strings
4. Summary

Collections?

Collection: group of objects identified as single object

- indexed
  - tuples $(a_0, a_1, a_2, \ldots a_n)$
    - points (x_0, y_0), (x_0, y_0, z_0)
  - lists $[a_0, a_1, \ldots, a_n]$
    - sequences $(a_0, a_1, a_2, \ldots)$
- not indexed
  - sets $\{a_0, a_5, a_3, a_2, a_1\}$
  - dictionaries

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Python collections

Standard Python collections

- *indexable* or *ordered* ("sequence types")
  - tuples, lists
  - access "element in position *i*" using `[i]`
    - but! start counting from `0`, **not 1**
- *not indexable* or *unordered* ("set types")
  - sets, dictionaries
  - only one instance of any element
  - access *an* element, but not "element in position *i*"

Tuples

tuple: immutable, ordered collection

- *immutable*: cannot change elements
- *indexable*: can access elements by their order
- defined using parentheses

Example

```
sage:  my_tuple = (1,5,0,5)                    4-tuple

sage:  my_tuple[2]                    access 3rd element (element 2)
0

sage:  my_tuple[2] = 1                         assign to 3rd element?
...Output deleted...
TypeError:  'tuple' object does not support item
assignment

sage:  my_tuple
(1,5,0,5)
```

Lists

list: mutable, ordered collection

- *mutable*: can change elements
- *indexable*: can access elements by their order
- defined using square brackets

Example

```
sage:  my_list = [1,5,0,5]
```
list of 4 elements

```
sage:  my_list[2]
0
```
access 3rd element (element 2)

```
sage:  my_list[2] = 1
```
assign to 3rd element?

```
sage:  my_list[2]
1
```
no error! access gives new value!

```
sage:  my_list
[1,5,1,5]
```

Sets

A **set** is a mutable, unordered collection

- *mutable*: can change elements
- *non-indexable*
  - cannot access elements by their order
  - computer arranges elements for efficiency
- defined using `set(`*tuple or list*`)` or `set()` (for empty set)
- redundant elements automatically deleted

Example

```
sage:  my_set = set([1,5,0,5])
```
set of 4 elements

```
sage:  my_set[2]
```
access 3rd element?

. . . Output deleted. . .

```
TypeError:  'set' object is unindexable
```

```
sage:  my_set
set([0, 1, 5])
```
so what's in there, anyway?

not original list!

Dictionaries

A **dictionary** is a mutable, undordered collection

- *mutable*: can change elements
- *non-indexable*
  - cannot access elements by their order
  - computer arranges elements for efficiency
- defined using `dict(`*list of tuples*`)` or $\{d_1 : a_1,\ d_2 : a_2,\ \ldots\}$
  - entry d_i has the "meaning" a_2
- redundant elements automatically deleted

Example

```
sage:  D = {1:3, 2:5}
```
dictionary w/2 entries

```
sage:  D[1]
3
```
entry "1" has meaning 3

```
sage:  D[0]
```
access element 0?

. . . Output deleted. . .

```
KeyError:  3
```

Nice dog! Does any tricks? (1)

sets, dictionaries, tuples, and lists

- `type(`*C*`)`
  type of C
- `len(`*C*`)`
  number of elements in C
- *x* `in` *C*
  is x an element of C?

tuples and lists

- *C*`.count(`*x*`)`
  Number of times x appears in C
- *C*`.index(`*x*`)`
  First location of x in C
- *C1* + *C2*
  join *C1* to *C2*, returned as new tuple/list

Example

```
sage:  len(my_set)
3

sage:  4 in my_set
False

sage:  5 in my_set
True

sage:  my_tuple.count(5)
2

sage:  my_list.index(5)
1

sage:  my_list + [1,3,5]
[1, 5, 0, 5, 1, 3, 5]
```

How many 5s?

in second location

Nice dog! Does any tricks? (2)

lists

*these commands **change the list***

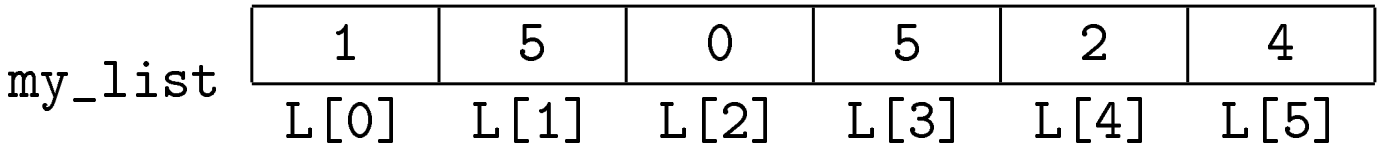
- `L.append(x)` — *add x at end of L*
- `L.extend(C)` — *append each element of C to L*
- `L.insert(i, x)` — *insert x at L[i], shifting L[i] and subsequent elements back*
- `L.pop(i)` — *delete L[i] and tell me its value*
- `L.remove(x)` — *look for x in L; remove first copy found*
- `L.reverse()`
- `L.sort()` — *sort L according to "natural" order*
  a good idea only for "primitive" elements

Example

```
sage:  my_list
[1, 5, 0, 5]

sage:  my_list.extend((2,4))

sage:  my_list
[1, 5, 0, 5, 2, 4]

sage:  my_list.insert(3,-1)

sage:  my_list
[1, 5, 0, -1, 5, 2, 4]

sage:  my_list.pop(3)
-1

sage:  my_list.sort()

sage:  my_list
[0, 1, 2, 4, 5, 5]
```

A word on inserting

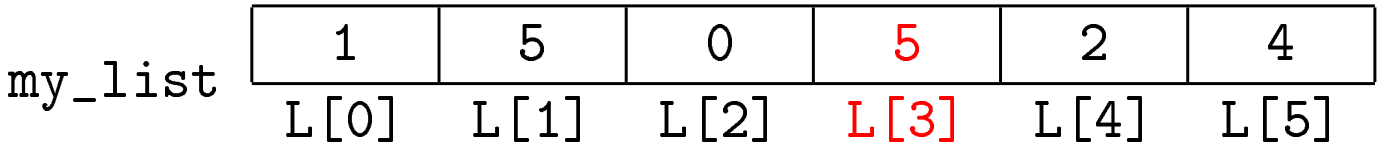
start:




```
sage:  my_list.insert(3,-1)
```

A word on inserting

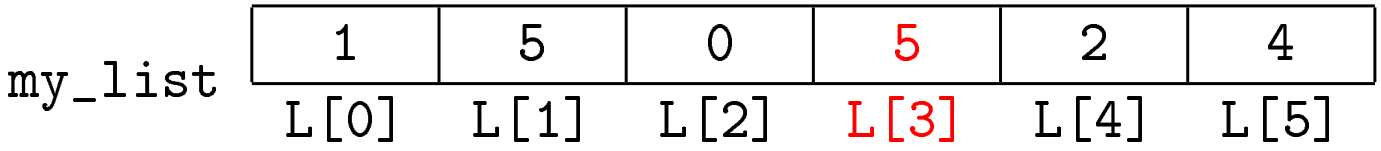
start:



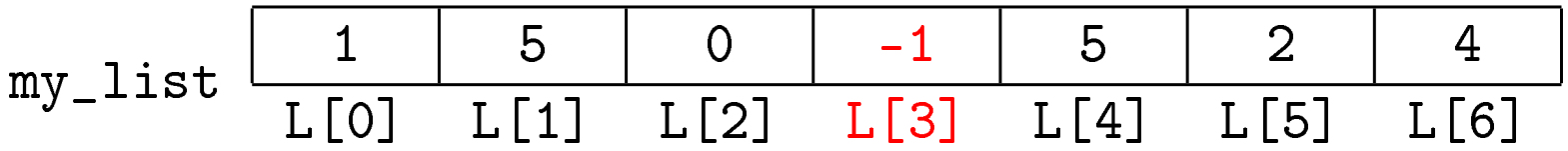

```
sage:  my_list.insert(3,-1)
```

A word on inserting

start:




```
sage:  my_list.insert(3,-1)
```



Nice dog! Does any tricks? (3)

sets as Python tools — *these commands **change the set***

- `S.add(x)`
- `S.clear()` — *remove all elements from S*
- `S.pop()` — *removes and reports random (first?) element of S*
- `S.remove(x)` — *remove x from S*

sets as mathematics — *these commands **do not** change the set*

- `S.difference(C)` — *difference* $S \setminus C$
- `S.intersection(C)` — *intersection* $S \cap C$
- `S.union(C)` — *union* $S \cup C$
- `S.isdisjoint(C)` — `True` *iff S and C share no elements*
- `S.symmetric_difference(C)` — *symmetric difference* $S \setminus C \cup C \setminus S$

Example

```
sage:  my_set = set((1,5,0,5))
sage:  my_set.add(4)
sage:  my_set
set([0, 1, 4, 5])
sage:  my_set.isdisjoint((-1,-2,4))
False
sage:  my_set.symmetric_difference((-1,-2,4))
set([-2, -1, 0, 1, 5])
sage:  my_set.remove(2)
...Output removed...
KeyError:  2
sage:  my_set.remove(1)
sage:  my_set
[0, 4, 5]
```

Nice dog! Does any tricks? (4)

dictionaries

*these commands **change the dictionary***

- D`.clear()` — *remove all elements from D*
- D`.pop(`d`)` — *remove entry for d from D*
- D`.popitem()` — *remove random entry from D*
- D`.update(`C`)` — *add definitions in C to D*

*these commands **do not** change the dictionary*

- D`.keys()` — *list the keys (entries) of D*
- D`.values()` — *list the values (definitions) of D*

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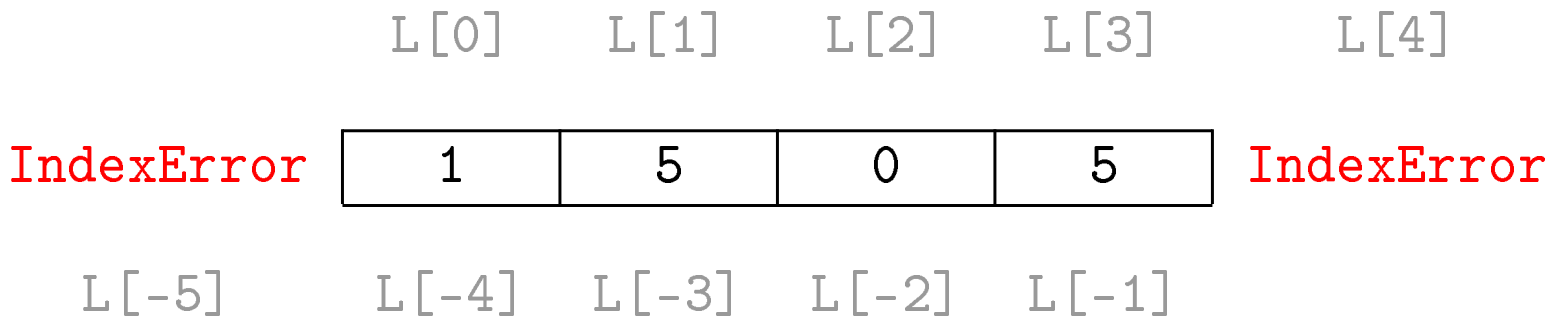
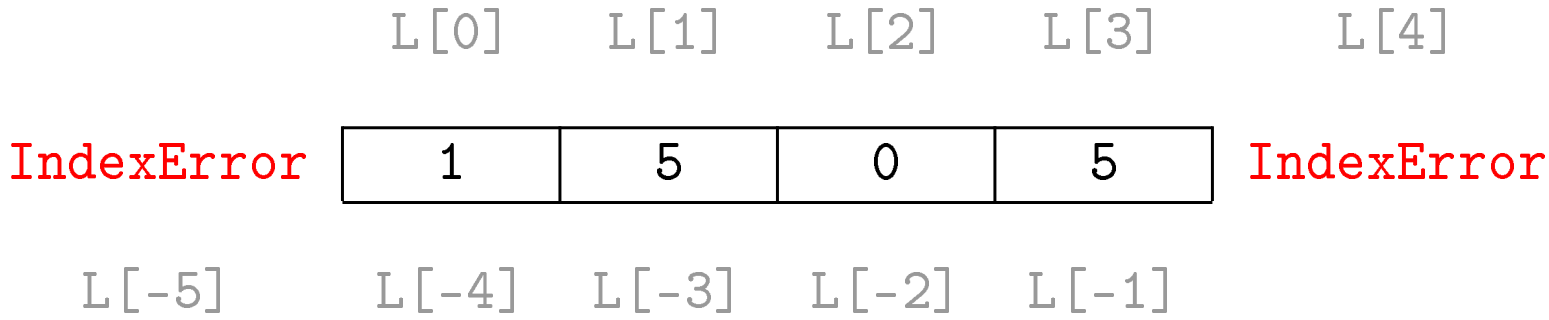
Tricks with []

Negative indices have meaning:



Tricks with []

Negative indices have meaning:



Example

```
sage:  L = [1,5,0,5]
sage:  L[-1]
5
sage:  L[-4]
1
sage:  L[-5]
...Output deleted...
IndexError:  list index out of range
```

Tricks with `[:]`

C`[` *first* `:` *last*$+1$ `]` specifies subcollection

C`[` *first* `]`	C`[` *first*$+1$ `]`	...	C`[` *last* `]`

- omit *first*? $\Longrightarrow$ start at `C[0]`
- omit *last*? $\Longrightarrow$ end at `C[-1]`

Tricks with [:]

C[*first* : *last*+1] specifies subcollection

C[*first*]	*C*[*first*+1]	...	*C*[*last*]

- omit *first*? $\Longrightarrow$ start at `C[0]`
- omit *last*? $\Longrightarrow$ end at `C[-1]`

Example

```
sage:  L[2:4]                                   L[2] to L[3]
[0, 5]
sage:  L[:2]                                    L[0] to L[1]
[1,5]
sage:  L[2:]                                    L[2] to L[-1]
[0,5]
sage:  L[:]                                     L[0] to L[-1]
[1,5,0,5]
```

The `range()` command

`range(` *first*, *last*+1 `)` generates list w/ *last* + 1 - *first* elements

- *first* indexes the first element
  - default value is `0`
- *last* indexes the last element
- *first* $\geq$ *last*? empty list

Example

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

sage:  range(1,5)
[1, 2, 3, 4]

sage:  range(3,5)
[3,4]

sage:  range(5,5)
[]

sage:  range(6,5)
[]
```

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Strings

String: ordered collection of characters

- extract elements using `[]`
- join elements using `+`
- other useful functions on pg. 96 of text

Example

```
sage:  name = 'Euler'
sage:  name[2]                          # 3rd character
'l'
sage:  name[-1]                         # last character
'r'
sage:  name[0:4]                        # first four characters in string
'Eule'
sage:  name + ' computed'               # add string; notice space
'Euler computed'
```

The `str()` command

`str(`x`)` where

- x is any object that can be turned into a string
- Sage will turn a *lot* of objects into strings!

Example

Numbers:

```
sage:  name + ' computed' + ' e**(i*pi) + 1 = '
         + str(0)
'Euler computed e**(i*pi) + 1 = 0'
```

Example

Numbers:

```
sage:  name + ' computed' + ' e**(i*pi) + 1 = '
         + str(0)
'Euler computed e**(i*pi) + 1 = 0'
```

Equations: (after "obvious" simplifications!)

```
sage:  name + ' computed ' + str(e**(i*pi) + 1 == 0)
'Euler computed 0 == 0'
```

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Summary

- Through Python, Sage offers several kinds of collections
  - tuples, lists, sets, dictionaries
- Operations
  - `[]` for extraction
    - negatives allowed
    - `[:]` gives subcollections
  - usual mathematical operations on sets
  - others supplied by Python
- Strings allow lists of characters
  - `str(`x`)` produces "obvious" string representation of x