# LISTS

## LECTURE 05-1

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# A NEED FOR DATA STRUCTURES

- We're limited in our coding if we can store values *only using individual variables*.

- What if we want to process...
  ...a file full of data? ...a web site full of statistics? ...a collection of items?

- Suppose for example, a user enters in some arbitrary number of values...
  - With single variables, we can't name all of them.

- Languages provide ***data structures*** to hold collections of values.
  - Python has two built into the language:
    - Python ***lists*** and Python ***dictionaries***.

# CRUD

- Whenever we study variables or data structures, think about the following operations on them:

  - Create
  - Read
  - Update
  - Delete

# OUR FIRST DATA STRUCTURE: PYTHON LISTS

- Python lets you represent sequences of data values:

```
>>> xs = [2,3,7,15,100]
>>> xs
[2, 3, 7, 15, 100]
>>> xs[3]
15
>>> xs[0]
2
>>> len(xs)
5
```

CREATE

READ

- This is a built-in data structure called a Python ***list***.
  - A list is a *sequence* of numbered slots; each slot stores a value.
  - Each slot can be accessed by its ***index***, starting at 0.
  - A list has a ***length***.

- A Python list is also our first explicit example of a Python (data) ***object***

# MODIFYING A LIST'S CONTENTS

- A Python list is a ***mutable*** data structure.
  - This means that its contents can be changed.

```
>>> xs
[2, 3, 7, 15, 100]
>>> xs[3]
15
>>> xs[3] = 200
>>> xs[3]
200
>>> xs
[2, 3, 7, 200, 100]
>>> xs[0] = xs[2] + xs[4]
>>> xs
[107, 3, 7, 200, 100]
>>> xs[4] = 1000
>>> xs
[107, 3, 7, 200, 1000]
>>> del xs[0]
[3, 7, 200, 1000]
```

UPDATE

DELETE

# LIST INDEXING

- You have to be careful when accessing a list; need to be mindful of its length.

```
>>> xs = [2,3,7,15,100]
>>> xs
[2, 3, 7, 15, 100]
>>> xs[5]
error!
```

- Using a negative index allows you to access backward from the end of the list:

```
>>> xs[-1]
100
>>> xs[-2]
15
>>> xs[-5]
2
>>> xs[-6]
error!
```

| xs | = [2, | 3, | 7, | 15, | 100] | |
|---|---|---|---|---|---|---|
| **Index** | **0** | 1 | 2 | 3 | 4 | ← indexing starts at **0** |
| **Index** | -5 | -4 | -3 | -2 | **-1** | ← Indexing ends at **-1** |

# EXAMPLE LIST FUNCTION: PALINDROME

- This checks a list to see if its contents read the same backwards as forwards:

```
def is_palindrome(xs):
    hi = len(xs)-1
    lo = 0
    while hi > lo:
        if xs[lo] != xs[hi]:
            return False
        lo = lo + 1
        hi = hi - 1
    return True
```

- Draw picture showing the pointers hi and lo moving

# EXAMPLE LIST FUNCTION: PALINDROME

- This does the same using negative indexing

```
def is_palindrome(xs):
    index = 0
    middle = len(xs) // 2
    while index < middle:
        if xs[index] != xs[-(index+1)]:
            return False
        index = index + 1
    return True
```

- Draw picture showing the pointers index and –(index+1) moving

# EXAMPLE LIST FUNCTION: COMPARE LISTS

- This checks to see if the contents of two lists are the same:

```
def same_contents(xs,ys):
    if len(xs) != len(ys):
        return False
    i = 0
    while i < len(xs):
        if xs[i] != ys[i]:
            return False
        i = i + 1
    return True
```

- What would happen if we don’t check the lengths of the lists first?

# EXAMPLE LIST FUNCTION: SEARCH

- This checks to see if the value **`y`** is stored in any of the slots of the list **`xs`**:

```
def contains(y,xs):
    i = 0
    while i < len(xs):
        if xs[i] == y:
            return True
        i = i + 1
    return False
```

- Can you rewrite this function with a for loop that loops over the indices of the list elements?

# LIST CONTENT CHECKS

- Python has **`contains`** and **`same_contents`** built into its language:

```
>>> 4 in [1,2,4,8] # Does the list contain an element?
True
>>> 7 in [1,2,4,8]
False
>>> xs = [1,3,4]
>>> ys = [1,3,5]
>>> xs == ys        # Are the lists' contents the same?
False
>>> xs != ys
True
>>> ys[2] = 4
>>> xs == ys
True
>>> xs != ys
False
>>> xs is ys        # Are they the same list object?
False
```

- The operators **`in`** and **`==`** check *contents*. The operator **`is`** checks list ***identity***.

# MODIFYING LISTS: ADDING AND INSERTING

- We can add more slots to a list object:

```
>>> xs = [13,5,71]
>>> xs
[13, 5, 71]
>>> xs.append(-57)          # Adds a new slot to the end.
>>> xs
[13, 5, 71, -57]
>>> xs.extend([7,8,9])      # Adds several slots to the end.
>>> xs
[13, 5, 71, -57, 7, 8, 9]
>>> xs.insert(2,100)        # Adds a slot in the middle.
>>> xs
[13, 5, 100, 71, -57, 7, 8, 9]
```

# MODIFYING LISTS: REMOVING

- We can remove slots from a list object:

```
>>> xs
[13, 5, 100, 71, -57, 7, 8, 9]
>>> xs.pop()     # Remove the last slot; return its value.
9
>>> xs
[13, 5, 100, 71, -57, 7, 8]
>>> xs[2]
100
>>> del xs[2]    # Remove a slot at a certain index.
>>> xs
[13, 5, 71, -57, 7, 8]
>>> xs[2]        # The other items shift left.
71
```

# EXAMPLE LIST FUNCTION

- This function builds a list of integers:

```
def count_up(n):
    i = 1
    counts = []
    while i <= n:
        counts.append(i)
        i = i + 1
    return counts

>>> count_up(7)
[1, 2, 3, 4, 5, 6, 7]
```

Can you rewrite this using a for loop?

# EXAMPLE LIST FUNCTION

- This function builds a number's divisor sequence:

```
def divisor_list(number):
    divisors = []
    d = 1
    while d <= number:
        if number % d == 0:
            divisors.append(d)
        d += 1
    return divisors

>>> divisor_list(35)
[1, 5, 7, 35]
>>> divisor_list(1)
[1]
>>> divisor_list(7)
[1, 7]
>>> divisor_list(36)
[1, 2, 3, 4, 6, 9, 12, 18, 26]
```

# EXAMPLE LIST PROCEDURE

- This function modifies a list.

```
def rotate_right(xs):
    if len(xs) > 1:
        last = xs.pop()
        xs.insert(0,last)
```

- Calling `rotate_right` has the ***side effect*** of changing the list you give it:

```
>>> lst = divisors_list(16)
>>> lst
[1, 2, 4, 8, 16]
>>> rotate_right(lst)
>>> lst
[16, 1, 2, 4, 8]
>>> rotate_right(lst)
>>> lst
[8, 16, 1, 2, 4]
```

# PYTHON LIST SUMMARY

- List creation via enumeration, concatenation, repetition, slicing:
  `[3,1,7]  []  [1,2]+[3,4,5]`
- Accessing contents by index; list length:
  `xs[3]  xs[-1]  len(xs)`
- Updating contents by indexed assignment:
  `xs[3] = 5`
- Modifying/mutating a list object:
  `xs.append(5)  xs.extend([8,9,10])  xs.insert(2,357)`
  `xs.pop()  del xs[6]`
- Checking membership, content equality, object identity:
  `3 in xs  xs == [1,2,3]  xs is ys`
- Scan according to index using a **`while`** loop:

```
i = 0
while i < len(xs):
    print(xs[i])
    i = i + 1
```