8.1 Lists

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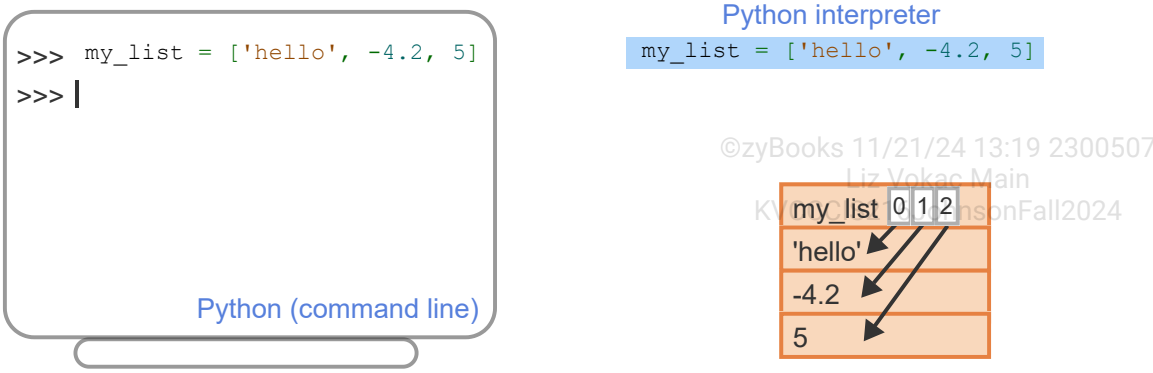
List basics

The list object type is one of the most important and often-used types in Python. Two terms that are used to define a list are container and mutable. A ***container*** is an object that groups related objects together. A ***list*** is a ***mutable*** container, meaning the size of the list can grow or shrink and elements within the list can change. A list is also a sequence; thus, the contained objects maintain a left-to-right positional order. Elements of the list can be accessed via indexing operations that specify the position of the desired element in the list. Each element in a list can be a different object type such as strings, integers, floats, or even other lists.

The animation below illustrates how a list is created using brackets `[]` around the list elements. The animation also shows how a list object contains references to the contained objects.

PARTICIPATION ACTIVITY 8.1.1: Lists contain references to other objects.



Animation content:

Static figure:
An empty container representing the command line.

Step 1:
The user creates a new list.
A line of code, my_list = ['hello', -4.2, 5], appears in the command line.
The line of code, my_list = ['hello', -4.2, 5], is sent to the Python interpreter.
An empty container with 4 cells is created.
The first cell is filled with my_list.

Step 2:
The interpreter creates a new object for each list element.
The second cell is filled with 'hello'.
The third cell is filled with -4.2.
The fourth cell is filled with 5.

Step 3:
'my_list' holds references to objects in the list.
Next to my_list in the first cell, are the references 0, 1, and 2.

Animation captions:

1. The user creates a new list.
2. The interpreter creates a new object for each list element.
3. 'my_list' holds references to objects in the list.

A list can also be created using the built-in list() function. The ***list()*** function accepts a single iterable object argument, such as a string, list, or tuple, and returns a new list object. Ex: `list('abc')` creates a new list with the elements ['a', 'b', 'c'].

PARTICIPATION ACTIVITY 8.1.2: List basics.

1) A program can modify the elements of an existing list.
   - ○ True
   - ○ False

2) The size of a list is determined when the list is created and cannot change.
   - ○ True

- False

3) All elements of a list must have the same type.

- True
- False

Accessing list elements

An ***index*** is a zero-based integer matching to a specific position in the list's sequence of elements. A programmer can reference a specific element in a list by providing an index. Ex: `my_list[4]` uses an integer to access the element at index 4 (the 5th element) of my_list.

An index can also be an expression, as long as that expression evaluates into an integer. Replacing the index with an integer variable, such as in `my_list[i]`, allows the programmer to quickly and easily lookup the (i+1)th element in a list.

zyDE 8.1.1: List's ith element can be directly accessed using [i]: Oldest people program.

Consider the following program that allows a user to print the age of the Nth oldest known person to have ever lived. Note: The ages are in a list sorted from oldest to youngest.

1. Modify the program to print the correct ordinal number ("1st", "2nd", "3rd", "4th", or "5th") instead of "1th", "2th", "3th", "4th", or "5th".
2. For the oldest person, remove the ordinal number (1st) from the print statement to say, "The oldest person lived 122 years".

Reminder: List indices begin at 0, not 1, thus the print statement uses oldest_people[nth_person-1], to access the nth_person element (element 1 at index 0, element 2 at index 1, etc.).

Load default template...

```
1 oldest_people = [122, 119, 11
2
3 nth_person = int(input('Enter
4
5 if (nth_person >= 1) and (nth
6     print(f'The {nth_person}t
7
```

3

Run

The program can quickly access the Nth oldest person's age using `oldest_people[nth_person-1]`. Note that the index is `nth_person-1` rather than just nth_person because a list's indices start at 0, so the first age is at index 0, the second at index 1, etc.

A list's index must be an integer type. The index cannot be a floating-point type, even if the value is 0.0, 1.0, etc.

PARTICIPATION ACTIVITY 8.1.3: List indices.

Given the following code, what is the output of each code segment?

```
animals = ['cat', 'dog', 'bird', 'raptor']
print(animals[0])
```

1) `print(animals[0])`

Check Show answer

2) `print(animals[2])`

Check Show answer

3) `print(animals[0 + 1])`

Check Show answer

4)

```
i = 3
print(animals[i])
```

Check Show answer

Common list operations and in-place list modification

The following table includes common operations performed on lists including creating lists, accessing list elements, slicing, and concatenation. Some of the operations might be familiar as sequence type operations also supported by strings. Note that slicing a list and concatenating two lists will return a new list.

Unlike the string sequence type, a list is mutable, meaning a list can grow and shrink without replacing the entire list with an updated copy. Such growing and shrinking capability is called ***in-place modification***. The dark-shaded rows highlight in-place modification operations.

Table 8.1.1: Some common list operations.

Operation	Description	Example code	Example output
my_list = [1, 2, 3]	Creates a list.	`my_list = [1, 2, 3]` `print(my_list)`	`[1, 2, 3]`
list(iter)	Creates a list.	`my_list = list('123')` `print(my_list)`	`['1', '2', '3']`
my_list[index]	Gets an element from a list.	`my_list = [1, 2, 3]` `print(my_list[1])`	`2`
my_list[start:end]	Gets a *new* list containing some of another list's elements.	`my_list = [1, 2, 3]` `print(my_list[1:3])`	`[2, 3]`
my_list1 + my_list2	Gets a *new* list with elements of my_list2 added to end of my_list1.	`my_list = [1, 2] + [3]` `print(my_list)`	`[1, 2, 3]`

my_list[i] = x	Changes the value of the element at index i in-place.	`my_list = [1, 2, 3]`
		`my_list[2] = 9`
		`print(my_list)`
			`[1, 2, 9]`

del my_list[i]	Deletes the element from index i from a list.	`my_list = [1, 2, 3]`
		`del my_list[1]`
		`print(my_list)`
			`[1, 3]`

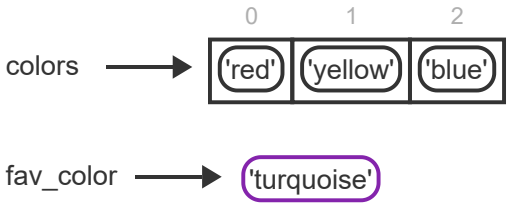
The below animation illustrates how a program can use in-place modifications to modify the contents of a list.

PARTICIPATION ACTIVITY 8.1.4: In-place modification of a list using indexing.


```
colors = ['red', 'green', 'blue']

colors[1] = 'yellow'  # Change list element
print(colors)

fav_color = colors[2]  # Bind to 'blue'
fav_color = 'turquoise'  # List not altered
print(colors)
```



['red', 'yellow', 'blue']
['red', 'yellow', 'blue']

Animation content:

Static figure:
Begin Python code block:
colors = ['red', 'green', 'blue']

colors[1] = 'yellow' # Change list element
print(colors)

fav_color = colors[2] # Bind to 'blue'
fav_color = 'turquoise' # List not altered
print(colors)
End Python code.

Step 1:
A list can be modified in place by assigning a specific list index with a new value.
The line of code, colors = ['red', 'green', 'blue'], executes.
A list is created named colors.
At index 0 is the string 'red'.
At index 1 is the string 'green'.
At index 2 is the string 'blue'.

The line of code, colors[1] = 'yellow' # Change list element, executes.
Index 1 of the list colors now contains the string 'yellow'.
The line of code, print(colors), executes.
['red', 'green', 'blue'] is outputted.

Step 2:
Assigning a variable with an element of an existing list, and then reassigning that variable with a different value does not modify the list.
The line of code, fav_color = colors[2] # Bind to 'blue', executes.
A variable fav_color is created and points to 'blue'.
The line of code, fav_color = 'turquoise' # List not altered, executes.
The variable fav_color now equals 'turquioise'.

Animation captions:

1. A list can be modified in place by assigning a specific list index with a new value.
2. Assigning a variable with an element of an existing list, and then reassigning that variable with a different value does not modify the list.

The difference between in-place modification of a list and an operation that creates an entirely new list is important. In-place modification affects any variable that references the list and can have unintended side effects. Consider the following code in which the variables your_teams and my_teams reference the same list (via the assignment `your_teams = my_teams`). If either your_teams or my_teams modifies an element of the list, then the change is reflected in the other variable as well.

The below Python Tutor tool executes a Python program and visually shows the objects and variables of a program. The tool shows names of variables on the left, with arrows connecting to bound objects on the right. Note that the tool does not show each number or string character as unique objects to improve clarity. The Python Tutor tool is available at www.pythontutor.com.

PythonTutor: In-place modification of a list.

```
1 my_teams = ['Raptors', 'Heat', 'Nets']
2 your_teams = my_teams  # Create a shared reference to same li
3
4 my_teams[1] = 'Lakers'  # Modify list element
5
6 print(f'My teams are: {my_teams}')  # Both variables have cha
7 print(f'Your teams are: {your_teams}')  # Both variables have
```


line that just executed
next line to execute

<< First | < Prev | Next > | Last >>

Step 1 of 5

Program output

Frames Objects

In the above example, changing the elements of my_teams also affects the contents of your_teams. The change occurs because my_teams and your_teams are bound to the same list object. The code `my_teams[1] = 'Lakers'` modifies the element in position 1 of the shared list object, thus changing the value of both my_teams[1] and your_teams[1].

The programmer of the above example probably meant to only change my_teams. The correct approach would have been to create a *copy* of the list instead. One simple method to create a copy is to use slice notation with no start or end indices, as in `your_teams = my_teams[:]`.

PythonTutor: In-place modification of a copy of a list.

```
1 my_teams = ['Raptors', 'Heat', 'Nets']
2 your_teams = my_teams[:]  # Assign your_teams with a COPY of
3
4 my_teams[1] = 'Lakers'  # Modify list element
5
6 print(f'My teams are: {my_teams}')  # List element has change
7 print(f'Your teams are: {your_teams}')  # List element has no
```


line that just executed
next line to execute

<< First | < Prev | Next > | Last >>

Step 1 of 5

Program output

Frames Objects

PARTICIPATION ACTIVITY 8.1.5: Common list operations.

1) Which statement deletes the third element from a list called my_list?

- `del my_list[2]`
- `del my_list(3)`
- `del my_list[3]`

2) Which operation does not perform an in-place modification?

- `my_list[j] = 3`
- `my_list[i + j] = 4`
- `my_list3 = my_list1 + my_list2`

3) Which statement creates a copy of a list?

- `my_copy = my_list`
- `my_copy = my_list[:]`

○ `my_copy[:] = my_list`

CHALLENGE ACTIVITY 8.1.1: Enter the output for the list.

566436.4601014.qx3zqy7

Start

Type the program's output

```
user_values = [1, 5, 9]

print(user_values)
```

```
[1, 5, 9]
```

1 2 3 4

Check Next

CHALLENGE ACTIVITY 8.1.2: Lists.

566436.4601014.qx3zqy7

Start

Seven values are read from input and stored in the list list_data. Output 'List item: ' followed by the third

▶ **Click here for example**

```
list_data = []
for elem in input().split():
    if elem.isdigit(): # If elem is a digit, then convert to int.
        list_data.append(int(elem))
    else:
        list_data.append(elem)

''' Your code goes here '''

```

1 2 3

Check Next level

8.2 List methods

Common list methods

A ***list method*** can perform a useful operation on a list such as adding or removing elements, sorting, reversing, etc.

The table below shows the available list methods. Many of the methods perform in-place modification of the list contents — a programmer should be aware that a method that modifies the list in-place changes the underlying list object, and thus may affect the value of a variable that references the object.

Table 8.2.1: Available list methods.

List method	Description	Code example	Final my_list value
Adding elements			
list.append(x)	Add an item to the end of list.	`my_list = [5, 8]` `my_list.append(16)`	`[5, 8, 16]`
list.extend([x])	Add all items in [x] to list.	`my_list = [5, 8]` `my_list.extend([4, 12])`	`[5, 8, 4, 12]`
list.insert(i, x)	Insert x into list *before* position i.	`my_list = [5, 8]` `my_list.insert(1, 1.7)`	`[5, 1.7, 8]`

List method	Description	Code example	Final my_list value

Removing elements

list.remove(x)	Remove first item from list with value x.	`my_list = [5, 8, 14]` `my_list.remove(8)`	`[5, 14]`
list.pop()	Remove and return last item in list.	`my_list = [5, 8, 14]` `val = my_list.pop()`	`[5, 8]` val is 14
list.pop(i)	Remove and return item at position i in list.	`my_list = [5, 8, 14]` `val = my_list.pop(0)`	`[8, 14]` val is 5

List method	Description	Code example	Final my_list value
Modifying elements			
list.sort()	Sort the items of list in-place.	`my_list = [14, 5, 8]` `my_list.sort()`	`[5, 8, 14]`
list.reverse()	Reverse the elements of list in-place.	`my_list = [14, 5, 8]` `my_list.reverse()`	`[8, 5, 14]`

List method	Description	Code example	Final my_list value
Miscellaneous			
list.index(x)	Return index of first item in list with value x.	`my_list = [5, 8, 14]` `print(my_list.index(14))`	Prints "2"
list.count(x)	Count the number of times value x is in list.	`my_list = [5, 8, 5, 5, 14]` `print(my_list.count(5))`	Prints "3"

A good practice is to use list methods to add and delete list elements, rather than alternative add/delete approaches. Alternative approaches include syntax such as `my_list[len(my_list):] = [val]` to add to a list, or `del my_list[0]` to remove from a list. Using a list method yields more readable code.

The list.sort() and list.reverse() methods rearrange a list element's ordering, performing in-place modification of the list.

The list.index() and list.count() return information about the list and do not modify the list.

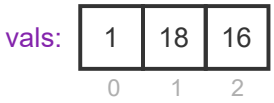
The below interactive tool shows a few of the list methods in action:

PARTICIPATION ACTIVITY 8.2.1: In-place modification using list methods.

```
vals = [1, 4, 16]

vals.append(9)
vals.insert(2, 18)
value = vals.pop()
vals.remove(4)
vals.remove(55)

#....
```



Animation content:

Static figure:
Begin Python code block:
vals = [1, 4, 16]

vals.append(9)
vals.insert(2, 18)
value = vals.pop()
vals.remove(4)
vals.remove(55)

#....
End code block.

Step 1:
vals is a list containing elements 1, 4, and 16.
A list is called vals created. Index 0 contains value 1. Index 1 contains value 2. Index 2 contains value 16.

Step 2:
The statement vals.append(9) appends element 9 to the end of the list.
Index 3 of vals now contains value 9.

Step 3:
The statement vals.insert(2, 18) inserts element 18 into position 2 of the list.
The values at index 2 and 3 are shifted to the right by one index. Value 18 is inserted to index 2.
vals list now contains values 1, 4, 18, 16, 9.

Step 4:
The statement vals.pop() removes the last element, 9, from the list.
vals list now contains values 1, 4, 18, 16.

Step 5:
The statement vals.remove(4) removes the first instance of element 4 from the list.
Index 1 of vals contains the value 4. Element 4 is removed from the list. The elements to the right of index 1 are shifted to the left one index.
vals list now contains values 1, 18, 16.

Step 6:
The statement vals.remove(55) removes the first instance of element 55 from the list. The list does not contain the element 55 so vals is the same.

Animation captions:

1. vals is a list containing elements 1, 4, and 16.
2. The statement vals.append(9) appends element 9 to the end of the list.
3. The statement vals.insert(2, 18) inserts element 18 into position 2 of the list.
4. The statement vals.pop() removes the last element, 9, from the list.
5. The statement vals.remove(4) removes the first instance of element 4 from the list.
6. The statement vals.remove(55) removes the first instance of element 55 from the list. The list does not contain the element 55 so vals is the same.

zyDE 8.2.1: Amusement park ride reservation system.

The following (unfinished) program implements a digital line queuing system for an amusement park ride. The system allows a rider to reserve a place in line without actually having to wait. The rider simply enters a name into a program to reserve a place. Riders that purchase a VIP pass get to skip past the common riders up to the last VIP rider in line. VIPs board the ride first. (Considering the average wait time for a Disneyland ride is about 45 minutes, this might be a useful program.)

For this system, an employee manually selects when the ride is dispatched (thus removing the next riders from the front of the line).

Complete the following program, as described above. Once finished, add the following commands:

- The rider can enter a name to find the current position in line. (Hint: Use the list.index() method.)
- The rider can enter a name to remove the rider from the line.

Load default template...

```
riders_per_ride = 3  # Num riders per ride to dispatch

line = []  # The line of riders
num_vips = 0  # Track number of VIPs at front of line

menu = ('(1) Reserve place in line.\n'  # Add rider to lir
        '(2) Reserve place in VIP line.\n'  # Add VIP
        '(3) Dispatch riders.\n'  # Dispatch next ride car
        '(4) Print riders.\n'
        '(5) Exit.\n\n')

user_input = input(menu).strip().lower()

while user_input != '5':
    if user_input == '1':  # Add rider
        name = input('Enter name:').strip().lower()
        print(name)
        line.append(name)
```

```
1
Frank
4
```

Run

PARTICIPATION ACTIVITY 8.2.2: List methods.

1) What is the output of the following program?

```
temps = [65, 67, 72, 75]
temps.append(77)
print(temps[-1])
```

Check Show answer

2) What is the output of the following program?

```
actors = ['Pitt', 'Damon']
actors.insert(1, 'Affleck')
print(actors[0], actors[1],
actors[2])
```


Check Show answer

3) Write the simplest two statements that first sort my_list, then remove the largest value element from the list, using list methods.

Check Show answer

4) Write a statement that counts the number of elements of my_list that have the value 15.

Check Show answer

CHALLENGE ACTIVITY 8.2.1: List methods.

566436.4601014.qx3zqy7

Start

Integer num_data is read from input, representing the number of integers to be read next. Read the rem and append each integer to data_list.

▶ **Click here for example**

```
num_data = int(input())

data_list = []

''' Your code goes here '''

```

```
print(data_list)
```


1 2

Check Next level

8.3 Iterating over a list

List iteration

A programmer accesses each element of a list. Thus, learning how to iterate through a list using a loop is critical.

Looping through a sequence such as a list is so common that Python supports a construct called a ***for loop***, specifically for iteration purposes. The format of a for loop is shown below.

Figure 8.3.1: Iterating through a list.

```
for my_var in my_list:
    # Loop body statements go
here
```


Each iteration of the loop creates a new variable by binding the next element of the list to the name my_var. The loop body statements execute during each iteration and can use the current value of my_var as necessary.

Programs commonly iterate through lists to determine some quantity about the list's items. Ex: The following program determines the value of the maximum even number in a list:

Figure 8.3.2: Iterating through a list example: Finding the maximum even number.

```
user_input = input('Enter numbers:')

tokens = user_input.split()  # Split into separate strings

# Convert strings to integers
nums = []
for token in tokens:
    nums.append(int(token))

# Print each position and number
print()  # Print a single newline
for index in range(len(nums)):
    value = nums[index]

    print(f'{index}: {value}')

# Determine maximum even number
max_num = None
for num in nums:
    if (max_num == None) and (num % 2 == 0):
        # First even number found
        max_num = num
    elif (max_num != None) and (num > max_num ) and (num % 2 == 0):
        # Larger even number found
        max_num = num

print(f'Max even #: {max_num}')
```

```
Enter numbers:3 5 23 -1 456 1 6 83
0: 3
1: 5
2: 23
3: -1
4: 456
5: 1
6: 6
7: 83
Max even #: 456
....
Enter numbers:-5 -10 -44 -2 -27 -9 -27 -9
0:-5
1:-10
2:-44
3:-2
4:-27
5:-9
6:-27
7:-9
Max even #: -2
```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Liz Vokac Main
KVCCCIS216JohnsonFall2024

If the user enters the numbers 7, -9, 55, 44, 20, -400, 0, 2, then the program will output `Max even #: 44`. The code uses three for loops. The first loop converts the strings obtained from the

split() function into integers. The second loop prints each of the entered numbers. The first and second loops could easily be combined into a single loop, but the example uses two loops for clarity. The third loop evaluates each of the list elements to find the maximum even number.

Before entering the first loop, the program creates the list nums as an empty list with the statement `nums = []`. The program then appends items to the list inside the first loop. Omitting the initial empty list creation would cause an error when the nums.append() function is called, because nums would not exist yet.

The main idea of the code is to use a variable max_num to maintain the largest value seen so far as the program iterates through the list. During each iteration, if the list's current element value is even and larger than max_num so far, then the program assigns max_num with current value. Using a variable to track a value while iterating over a list is common behavior.

PARTICIPATION ACTIVITY 8.3.1: Using a variable to keep track of a value while iterating over a list.

```
nums = [1, 4, 15, 456]

max_even = None
for num in nums:
    if num % 2 == 0: # The number is even?
        if max_even == None or num > max_even:  # Greatest even number seen?
            max_even = num
```

num: 456

max_even: 456

Finding the maximum even number in a list by iterating over every element.

Animation content:

Static figure:
Begin Python code block:
nums = [1, 4, 15, 456]

max_even = None
for num in nums:
  if num % 2 == 0: # The number is even?
    if max_even == None or num > max_even: # Greatest even number seen?
      max_even = num
End code block.

Step 1:

Loop iterates over all elements of list nums.
max_even set to None.
First iteration of the for loop. num is set to 1. num is not even. First iteration of the for loops ends.

Step 2:
Only larger even numbers update the value of max_even.
Second iteration of the for loop. num is set to 4. max_even is set to 4.

Step 3:
Odd numbers, or numbers smaller than max_even, are ignored.
Next iteration of the for loop. num is set to 15. num is not even. This iteration of the for loop ends.

Step 4:
When the loop ends, max_even is set to the largest even number 456.
Last iteration of the for loop. num is set to 456. num is greater than max_even. max_even is not set to 456.
For loop ends.

Animation captions:

1. Loop iterates over all elements of list nums.
2. Only larger even numbers update the value of max_even.
3. Odd numbers, or numbers smaller than max_even, are ignored.
4. When the loop ends, max_even is set to the largest even number 456.

A logic error in the above program would be to set max_even initially to 0 and then test `if max_even == 0`, because 0 is not in fact the largest value seen so far. Also, if the list nums only includes 0 and negative numbers, max_even would be assigned with the largest negative number that comes after 0 in the list even though max_even should be 0. Ex: `nums = [-1, 0, -16, -2]` would result in max_even being assigned with -2. Instead, the program sets max_even to None.

PARTICIPATION ACTIVITY 8.3.2: List iteration.

Fill in the missing field to complete the program.

1) Count how many odd numbers (cnt_odd) there are.


```
cnt_odd =
for i in num:
    if i % 2 == 1:
        cnt_odd += 1
```

Check Show answer

2) Count how many negative numbers (cnt_neg) there are.

```
cnt_neg = 0
for i in num:
    if i < 0:
        
```

Check Show answer

3) Determine the number of elements in the list that are divisible by 10. (Hint: The number x is divisible by 10 if x % 10 is 0.)

```
div_ten = 0
for i in num:
    if :
        div_ten += 1
```

Check Show answer

For loops with iterable objects

A for loop works on any iterable object. An iterable object is any object that can access each of its elements one at a time for most sequences such as lists, strings, and tuples are iterables. Thus, for loops are not specific to lists.

IndexError and enumerate()

A common error is to try to access a list with an index that is out of the list's index range, e.g., to try to access my_list[8] when my_list's valid indices are 0-7. Accessing an index that is out of range causes the program to automatically abort execution and generate an ***IndexError***. Ex: For a list my_list containing 8 elements, the statement `my_list[10] = 42` produces output similar to:

```
Traceback (most recent call last):
  File "<stdin>", line 1, in <module>
IndexError: list assignment index out of range
```

Iterating through a list for various purposes is an extremely important programming skill to master.

zyDE 8.3.1: Iterating through a list example: Finding the sum of a list's elements.

Here is another example computing the sum of a list of integers. Note that the code is somewhat different than the code computing the max even value. For computing the sum, the program initializes a variable sum to 0, then simply adds the current iteration's list element value to that sum.

Run the program below and observe the output. Next, modify the program to calculate the following:

- Compute the average, as well as the sum. Hint: Don't change the loop, just change the printed value.
- Print each number that is greater than 21.

Load default template...

```
# User inputs string w/ nu
user_input = input('Enter

tokens = user_input.split(

# Convert strings to integ
print()
nums = []
for pos, token in enumerat
    nums.append(int(token)
    print(f'{pos}: {token}

sum = 0
for num in nums:
    sum += num

print(f'Sum: {sum}')
```

203 12 5 800 -10

Run

The built-in ***enumerate()*** function iterates over a list and provides an iteration counter. The program above uses the enumerate() function, which results in the variables pos and token being assigned the current loop iteration element's index and value, respectively. Thus, the first iteration of the loop assigns pos with 0 and token with the first user number; the second iteration assigns pos with 1 and token with the second user number; and so on.

Built-in functions that iterate over lists

Iterating through a list to find or calculate certain values like the minimum/maximum or sum is so common that Python provides built-in functions as shortcuts. Instead of writing a for loop and tracking a

maximum value, or adding a sum, a programmer can use a statement such as `max(my_list)` or `sum(my_list)` to quickly obtain the desired value.

Table 8.3.1: Built-in functions supporting list objects.

Function	Description	Example code	Example output
all(list)	True if every element in list is True (!= 0), or if the list is empty.	`print(all([1, 2, 3]))` `print(all([0, 1, 2]))`	`True` `False`
any(list)	True if any element in the list is True.	`print(any([0, 2]))` `print(any([0, 0]))`	`True` `False`
max(list)	Get the maximum element in the list.	`print(max([-3, 5, 25]))`	`25`
min(list)	Get the minimum element in the list.	`print(min([-3, 5, 25]))`	`-3`
sum(list)	Get the sum of all elements in the list.	`print(sum([-3, 5, 25]))`	`27`

zyDE 8.3.2: Using built-in functions with lists.

Complete the following program using functions from the table above to find some statistics about basketball player Lebron James. The code below provides lists of various statistical categories for the years 2003-2013. Compute and print the following statistics:

- Total career points
- Average points per game
- Years of the highest and lowest scoring season

Use loops where appropriate.

Load default template... Run

```
1
2 #Lebron James: Statistics
3 games_played = [79, 80, 79
4 points = [1654, 2175, 2478
5 assists = [460, 636, 814,
```

```
rebounds = [432, 588, 556,

# Print total points

# Print Average PPG

# Print best scoring years

# Print worst scoring year
```


PARTICIPATION ACTIVITY 8.3.3: Lists and built-in functions.

Assume that my_list is [0, 5, 10, 15].

1) What value is returned by sum(my_list)?

Check Show answer

2) What value is returned by max(my_list)?

Check Show answer

3) What value is returned by any(my_list)?

Check Show answer

4) What value is returned by all(my_list)?

Check Show answer

5) What value is returned by min(my_list)?

Check Show answer

CHALLENGE ACTIVITY 8.3.1: Sum extra credit.

Assign sum_extra with the total extra credit received given list test_grades. Iterate through the list with `for grade in test_grades:`. The code uses the Python split() method to split a string at each space into a list of string values and the map() function to convert each string value to an integer. Full credit is 100, so anything over 100 is extra credit.

Sample output for the given program with input: '101 83 107 90'

```
Sum extra: 8
```

(because 1 + 0 + 7 + 0 is 8)

Learn how our autograder works

566436.4601014.qx3zqy7

```
user_input = input()
test_grades = list(map(int, user_input.split())) # test_grades is an integer list of


sum_extra = 0 # Initialize 0 before your loop

''' Your solution goes here '''

print(f'Sum extra: {sum_extra}')
```


Run

View your last submission

CHALLENGE ACTIVITY 8.3.2: Iterating over a list.

566436.4601014.qx3zqy7

Start

List experiment_data contains integers read from input, representing data samples from an experiment. Append to experiment_data:

- If the element's value is greater than or equal to 40, then increment ok_count and output 'Sample ' index, and ' is ok'.
- Otherwise, output 'Sample ', followed by the element's index, and ' needs attention'.

▶ **Click here for example**

```
# Read input and split input into tokens
tokens = input().split()

experiment_data = []
for token in tokens:
    experiment_data.append(int(token))

print(f'Raw samples: {experiment_data}')

ok_count = 0

''' Your code goes here '''

print(f'Total ok samples: {ok_count}')
```

1 2

Check Next level

8.4 List games

The following activities can help programmers become comfortable with iterating through lists. Challenge yourself with these list games.

PARTICIPATION ACTIVITY 8.4.1: Find the maximum value in the list.

If a new maximum value is seen, click 'Store value'. Try again to get the best time.

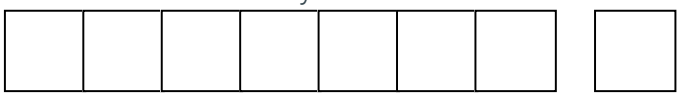
Start

Next value Store value

PARTICIPATION ACTIVITY 8.4.2: Negative value counting in list.

If a negative value is seen, click 'Increment'. Try again to get the best time.

Start

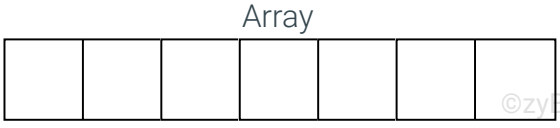


Next value Increment

PARTICIPATION ACTIVITY 8.4.3: Manually sorting largest value.

Move the largest value to the right-most position of the list. If the larger of the two current values is on the left, swap the values. Try again to get the best time.

Start



Next value Swap values

8.5 List nesting

Since a list can contain any type of object as an element, and a list is itself an object, a list can contain another list as an element. Such embedding of a list inside another list is known as ***list nesting***. Ex: The code `my_list = [[5, 13], [50, 75, 100]]` creates a list with two elements that are each another list.

Figure 8.5.1: Multi-dimensional lists.

```
my_list = [[10, 20], [30, 40]]
print(f'First nested list: {my_list[0]}')
print(f'Second nested list: {my_list[1]}')
print(f'Element 0 of first nested list: {my_list[0][0]}')
```

```
First nested list: [10, 20]
Second nested list: [30, 40]
Element 0 of first nested list: 10
```

The program accesses elements of a nested list using syntax such as my_list[0][0].

PARTICIPATION ACTIVITY 8.5.1: List nesting.

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

my_list[0]
['a', 'b']
my_list[0][0] = 'a'
my_list[0][1] = 'b'

my_list[1]
['c', 'd']
my_list[1][0] = 'c'
my_list[1][1] = 'd'

my_list[2]
['e', 'f']
my_list[2][0] = 'e'
my_list[2][1] = 'f'

Animation content:

Static figure:
Begin Python code block:
my_list = [['a', 'b'], ['c', 'd'], ['e', 'f']]

End code block.

Step 1:
The nested lists can be accessed using a single access operation.
my_list[0] is equal to ['a', 'b'].
my_list[1] is equal to ['c', 'd'].
my_list[2] is equal to ['e', 'f'].

Step 2:
The elements of each nested list can be accessed using two indexing operations.
my_list[0][0] is equal to 'a'.
my_list[0][1] is equal to 'b'.
my_list[1][0] is equal to 'c'.
my_list[1][1] is equal to 'd'.
my_list[2][0] is equal to 'e'.
my_list[2][1] is equal to 'f'.

Animation captions:

1. The nested lists can be accessed using a single access operation.
2. The elements of each nested list can be accessed using two indexing operations.

PARTICIPATION ACTIVITY 8.5.2: List nesting.

1) Given the list nums = [[10, 20, 30], [98, 99]], what does nums[0][0] evaluate to?

Check Show answer

2) Given the list nums = [[10, 20, 30], [98, 99]], what does nums[1][1] evaluate to?

Check Show answer

3) Given the list nums = [[10, 20, 30], [98, 99]], what does nums[0] evaluate to?

Check Show answer

4) Create a nested list called nums whose only element is the list [21, 22, 23].

Check Show answer

A list is a single-dimensional sequence of items, like a series of times, data samples, daily temperatures, etc. List nesting allows for a programmer to also create a ***multi-dimensional data structure***, the simplest being a two-dimensional table, like a spreadsheet or tic-tac-toe board. The following code defines a two-dimensional table using nested lists:

Figure 8.5.2: Representing a tic-tac-toe board using nested lists.

```
tic_tac_toe = [
    ['X', 'O', 'X'],
    [' ', 'X', ' '],
    ['O', 'O', 'X']
]

print(tic_tac_toe[0][0], tic_tac_toe[0][1], tic_tac_toe[0][2])
print(tic_tac_toe[1][0], tic_tac_toe[1][1], tic_tac_toe[1][2])
print(tic_tac_toe[2][0], tic_tac_toe[2][1], tic_tac_toe[2][2])
```

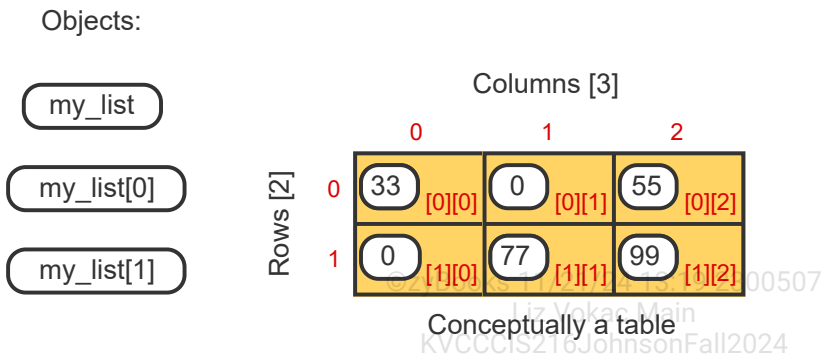
```
X O X
  X
O O X
```

The example above creates a variable tic_tac_toe that represents a two-dimensional table with three rows and three columns, for 3*3=9 total table entries. Each row in the table is a nested list. Table entries can be accessed by specifying the desired row and column: tic_tac_toe [1][1] accesses the middle square in row 1, column 1 (starting from 0), which has a value of 'X'. The following animation illustrates:

PARTICIPATION ACTIVITY 8.5.3: Two-dimensional list.

```
my_list = [
    [10, 0, 55],
    [0, 4, 16]
]

# Write to some elements
my_list[0][0] = 33
my_list[1][1] = 77
my_list[1][2] = 99
```



Conceptually a table

Animation content:

Static figure:
Begin Python code:
my_list = [
  [10, 0, 55],
  [0, 4, 16]
]
# Write to some elements
my_list[0][0] = 33
my_list[1][1] = 77
my_list[1][2] = 99
End Python code.

Step 1: New list object contains other lists as elements.
List my_list contains two lists as elements: my_list[0] is [10, 0, 55] and my_list[1] is [0, 4, 16].

my_list conceptually as a table with 2 rows and 3 columns.

	Column 0	Column 1	Column 2
Row 0	10, accessed by [0][0]	0, accessed by [0][1]	55, accessed by [0][2]
Row 1	0, accessed by [1][0]	4, accessed by [1][1]	16, accessed by [1][2]

Step 2: Elements accessed by [row][column].

my_list conceptually as a table after the following three lines of code are executed:
my_list[0][0] = 33
my_list[1][1] = 77

my_list[1][2] = 99

	Column 0	Column 1	Column 2
Row 0	previously 10, updated to 33	0	55
Row 1	0	previously 4, updated to 77	previously 16, updated to 99

Animation captions:

1. New list object contains other lists as elements.
2. Elements accessed by [row][column].

zyDE 8.5.1: Two-dimensional list example: Driving distance between cities.

The following example illustrates the use of a two-dimensional list in a distance between cities.

Run the following program, entering the text '1 2' as input to find the distance between LA and Chicago. Try other pairs. Next, try modifying the program by adding a new city, Anchorage, that is 3400, 3571, and 4551 miles from Los Angeles, Chicago, and Boston, respectively.

Note that the styling of the nested list in this example makes use of indentation to clearly indicate the elements of each list. The spacing does not affect how the interpreter evaluates the list contents.

Load default template...

```
# direct driving distances
# 0: Boston    1: Chicago

distances = [
    [
        0,
        960,  # Boston-Chi
        2960 # Boston-Los
    ],
    [
        960,  # Chicago-Bo
        0,
        2011  # Chicago-Lo
    ],
    [
        2960,  # Los Angel
        2011,  # Los Angel
```

1 2

Run

The level of nested lists is arbitrary. A programmer might create a three-dimensional list structure as follows:

Figure 8.5.3: The level of nested lists is arbitrary.

```
nested_table = [
    [
        [10, 0,
55],
        [0, 4, 16]
    ],
    [
        [0, 0, 1],
        [1, 20, 2]
    ]
]
```


A number from the above three-dimensional list could be accessed using three indexing operations, as in `nested_table[1][1][1]`.

PARTICIPATION ACTIVITY 8.5.4: Multi-dimensional lists.

Assume the following list has been created

```
scores = [
    [75, 100, 82, 76],
    [85, 98, 89, 99],
    [75, 82, 85, 5]
]
```

1) Write an indexing expression that gets the element from scores whose value is 100.

Check Show answer

2) How many elements does scores contain? (The result of len(scores))

Check Show answer

As always with lists, a typical task is to iterate through the list elements. A programmer can access all of the elements of nested lists by using ***nested for loops***. The first for loop iterates through the elements of the outer list (rows of a table), while the nested loop iterates through the inner list elements (columns of a table). The code below defines a 3x3 table and iterates through each of the table entries.

PARTICIPATION ACTIVITY 8.5.5: Iterating over multi-dimensional lists.


```
currency = [
                        cell
        [1.00, 5.00, 10.0], # US Dollars
        [0.75, 3.77, 7.53], # Euros
 row --> [0.65, 3.25, 6.50]  # British pounds
]

for row in currency:
    for cell in row:
        print(cell, end=' ')
    print()
```

1.00	5.00	10.0
0.75	3.77	7.53
0.65	3.25	6.50

Animation content:

Static figure:
Begin Python code:
currency = [

[1.00, 5.00, 10.0], # US Dollars
[0.75, 3.77, 7.53], # Euros
[0.65, 3.25, 6.50] # British pounds
]

for row in currency:
  for cell in row:
    print(cell, end=' ')
  print()
End Python code.

In the program's nested for loop, the outer loop iterates three times, once for each row within list currency. For each iteration of the outer loop, the inner loop iterates three times, once for each cell within the row. The inner loop's print statement outputs cell's value followed by a space. After the inner loop terminates, the outer loop prints a newline and proceeds to the next iteration. After three iterations of the outer loop, the outer loop terminates.

Step 1: Each iteration row is assigned the next list element from currency. Each item in a row is printed in the inner loop.

Outer loop iteration	Inner loop iteration	Output console
1	1	1.00
1	2	1.00 5.00
1	3	1.00 5.00 10.00
2	1	1.00 5.00 10.00 0.75
2	2	1.00 5.00 10.00 0.75 3.77
2	3	1.00 5.00 10.00 0.75 3.77 7.53
3	1	1.00 5.00 10.00 0.75 3.77 7.53 0.65
3	2	1.00 5.00 10.00 0.75 3.77 7.53 0.65 3.25
3	3	1.00 5.00 10.00 0.75 3.77 7.53 0.65 3.25 6.50

Animation captions:

1. Each iteration row is assigned the next list element from currency. Each item in a row is printed in the inner loop.

The outer loop assigns the variable row with one of the list elements. The inner loop then iterates over the elements in that list. Ex: On the first iteration of the outer loop, row is [1, 5, 10]. The inner loop then assigns cell 1 on the first iteration, 5 on the second iteration, and 10 on the last iteration.

Combining nested for loops with the enumerate() function gives easy access to the current row and column below.

Figure 8.5.4: Iterating through multi-dimensional lists using enumerate().

```
currency = [
   [1, 5, 10 ],   # US Dollars
   [0.75, 3.77, 7.53],   #Euros
   [0.65, 3.25, 6.50]   # British pounds
]
for row_index, row in enumerate(currency):
   for column_index, item in enumerate(row):
      print(f'currency[{row_index}][{column_index}]
is {item:.2f}')
```

```
currency[0][0] is
1.00
currency[0][1] is
5.00
currency[0][2] is
10.00
currency[1][0] is
0.75
currency[1][1] is
3.77
currency[1][2] is
7.53
currency[2][0] is
0.65
currency[2][1] is
3.25
currency[2][2] is
6.50
```


PARTICIPATION ACTIVITY 8.5.6: Find the error.

The desired output and actual output of each program is given. Find the error in each program.

1)

Desired output:

```
0 2 4 6
0 3 6 9 12
```

Actual output:

```
[0, 2, 4, 6] [0, 3, 6, 9, 12]
[0, 2, 4, 6] [0, 3, 6, 9, 12]
```

```
nums = [
   [0, 2, 4, 6],
   [0, 3, 6, 9, 12]
]

for n1 in nums :
   for n2 in nums :
      print(n2, end=' ')
   print()
```

2)

Desired output: `X wins!`

Actual output: `Cat's game!`

```
tictactoe = [
   ['X', 'O', 'O'],
   ['O', 'O', 'X'],
   ['X', 'X', 'X']
]

# Check for 3 Xs in one row
# (Doesn't check columns or diagonals)
for row in tictactoe
:
   num_X_in_row = 0
   for square in row
:
      if square == 'X'
:
         num_X_in_row += 1
   if num_X_in_row == square
:
      print('X wins!')
      break
else:
   print("Cat's game!")
```


CHALLENGE ACTIVITY 8.5.1: List nesting.

566436.4601014.qx3zqy7

Start

Lists row1 and row2 are read from input. Assign list_2d with a two-dimensional list consisting of row1 a

▶ **Click here for example**

```
row1 = input().split()
row2 = input().split()

''' Your code goes here '''

print(list_2d[0])
print(list_2d[1])
```

1 2 3

Check Next level

8.6 List slicing

A programmer can use ***slice notation*** to read multiple elements from a list, creating a new list that contains only the desired elements. The programmer indicates the start and end positions of a range of elements to retrieve, as in `my_list[0:2]`. The 0 is the position of the first element to read, and the 2 indicates the last element. Every element between 0 and 2 from my_list is in the new list. The end position, 2, is *not* included in the resulting list.

Figure 8.6.1: List slice notation.

```
boston_bruins = ['Tyler', 'Zdeno',
'Patrice']
print(f'Elements 0 and 1:
{boston_bruins[0:2]}')
print(f'Elements 1 and 2:
{boston_bruins[1:3]}')
```

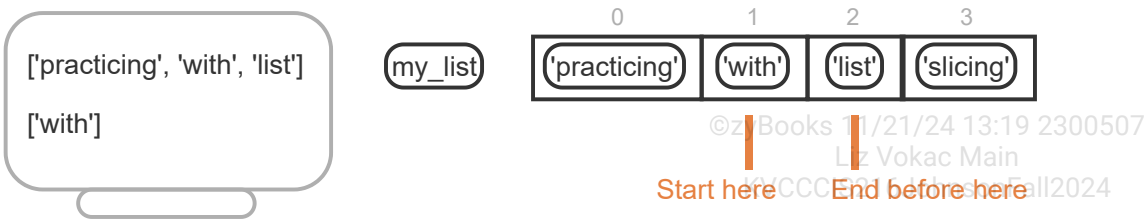
```
Elements 0 and 1: ['Tyler',
'Zdeno']
Elements 1 and 2: ['Zdeno',
'Patrice']
```

The slice `boston_bruins[0:2]` produces a new list containing the elements in positions 0 and 1: ['Tyler', 'Zdeno']. The end position is *not* included in the produced list – to include the final element of a list in a slice, specify an end position past the end of the list. Ex: `boston_bruins[1:3]` produces the list ['Zdeno', 'Patrice'].

PARTICIPATION ACTIVITY 8.6.1: List slicing.

```
my_list = ['practicing', 'with', 'list', 'slicing']
```

```
print(my_list[0:3])
print(my_list[1:2])
```



Animation content:

Static figure:
Begin Python code:
my_list = ['practicing', 'with', 'list', 'slicing']

print(my_list[0:3])
print(my_list[1:2])
End Python code.

Step 1: The list object is created. List my_list contains 4 elements from index 0 to index 3.

Index	Element's value
0	'practicing'
1	'with'
2	'list'
3	'slicing'

Step 2: The list is sliced from 0 to 3, and then printed out.
print(my_list[0:3]) produces a new list containing the elements from indices 0 to 2, then outputs the new list to the console. The end position, position 3 with value 'slicing', is not included in the produced list. Thus, the output to the console is ['practicing', 'with', 'list'] followed by a newline.

Step 3: The list is sliced from 1 up to 2.
print(my_list[1:2]) produces a new list containing the element at index 1, then outputs the new list to the console. The end position, position 2 with value 'list', is not included in the produced list.Thus, the output to the console is ['with'] followed by a newline.

Animation captions:

1. The list object is created.
2. The list is sliced from 0 to 3, and then printed out.
3. The list is sliced from 1 up to 2.

Negative indices can also be used to count backward from the end of the list.

Figure 8.6.2: List slicing: Using negative indices.

```
election_years = [1992, 1996, 2000, 2004, 2008]
print(election_years[0:-1])   # Every year except the
last
print(election_years[0:-3])   # Every year except the
last three
print(election_years[-3:-1])   # The third and second to
last years
```

```
[1992, 1996, 2000,
2004]
[1992, 1996]
[2000, 2004]
```

A position of -1 refers to the last element of the list, thus election_years[0:-1] creates a slice containing all but the last election year. Such usage of negative indices is especially useful when the length of a list is not known and is simpler than the equivalent expression election_years[0:len(election_years)-1].

PARTICIPATION ACTIVITY 8.6.2: List slicing.

Assume that the following code has been evaluated:

```
nums = [1, 1, 2, 3, 5, 8, 13]
```

1) What is the result of nums[1:5]?

Check Show answer

2) What is the result of nums[5:10]?

Check Show answer

3) What is the result of nums[3:-1]?

Check Show answer

An optional component of slice notation is the ***stride***, which indicates how many elements are skipped between extracted items in the source list. Ex: The expression my_list[0:5:2] has a stride of 2, thus skipping every other element, and resulting in a slice that contains the elements in positions 0, 2, and 4. The default stride value is 1 (the expressions my_list[0:5:1] and my_list[0:5] being equivalent).

If the reader has studied string slicing, then list slicing should be familiar. In fact, slicing has the same semantics for most sequence-type objects.

PARTICIPATION ACTIVITY 8.6.3: List slicing.

Given the following code:

```
nums = [0, 25, 50, 75, 100]
```

1) The result of evaluating nums[0:5:2] is [25, 75].
   - True
   - False

2) The result of evaluating nums[0:-1:3] is [0, 75].
   - True
   - False

A table of common list slicing operations is given below. Note that omission of the start or end positions, such as my_list[:2] or my_list[4:], has the same meaning as in string slicing. my_list[:2] includes every element up to position 2. my_list[4:] includes every element following position 4 (including the element at position 4).

Table 8.6.1: Common list slicing operations.

Operation	Description	Example code	Example output
my_list[start:end]	Get a list from start	`my_list = [5, 10, 20]` `print(my_list[0:2])`	`[5, 10]`

	to end (minus 1).		
my_list[start:end:stride]	Get a list of every stride element from start to end (minus 1).	`my_list = [5, 10, 20, 40, 80]` `print(my_list[0:5:3])`	`[5, 40]`
my_list[start:]	Get a list from start to end of the list.	`my_list = [5, 10, 20, 40, 80]` `print(my_list[2:])`	`[20, 40, 80]`
my_list[:end]	Get a list from beginning of the list to the end (minus 1).	`my_list = [5, 10, 20, 40, 80]` `print(my_list[:4])`	`[5, 10, 20, 40]`
my_list[:]	Get a copy of the list.	`my_list = [5, 10, 20, 40, 80]` `print(my_list[:])`	`[5, 10, 20, 40, 80]`

The interpreter handles incorrect or invalid start and end positions in slice notation gracefully. An end position that exceeds the length of the list is treated as the end of the list. If the end position is less than the start position, an empty list is produced.

PARTICIPATION ACTIVITY 8.6.4: Match the expressions to the list.

Match the expression on the left to the resulting list on the right. Assume that my_list is the following Fibonacci sequence:


```
my_list = [1, 1, 2, 3, 5, 8, 13, 21, 34]
```

If unable to drag and drop, refresh the page.

my_list[2:5] | my_list[len(my_list)//2:(len(my_list)//2) + 1] | my_list[:20] | my_list[3:6]

my_list[4:] my_list[3:1]

	[5, 8, 13, 21, 34]
	[]
	[1, 1, 2, 3, 5, 8, 13, 21, 34]
	[5]
	[2, 3, 5]
	[3, 5, 8]

Reset

CHALLENGE ACTIVITY 8.6.1: Enter the output of the sliced list.

566436.4601014.qx3zqy7

Start

Type the program's output

```
my_list = [13, 14, 15, 16, 17, 18, 19]
new_list = my_list[0:3]
print(new_list)
```

[13, 14, 15]

1 2 3 4

Check Next

CHALLENGE ACTIVITY 8.6.2: List slicing.

566436.4601014.qx3zqy7

Start

List florists_list is read from input. Assign selected_florists with a slice of florists_list from the second e excluding the last three elements.

▶ **Click here for example**

```
florists_list = input().split()

''' Your code goes here '''

print(f'Original list of florists: {florists_list}')
print(f'Selected list of florists: {selected_florists}')
```


1 2

Check Next level

8.7 Loops modifying lists

Sometimes a program iterates over a list while modifying the elements, such as changing some elements' values or moving elements' positions.

Changing elements' values

The below example of changing elements' values combines the len() and range() functions to iterate over a list and increment each element of the list by 5.

Figure 8.7.1: Modifying a list during an iteration example.

```
my_list = [3.2, 5.0, 16.5,
12.25]

for i in range(len(my_list)):
    my_list[ i ] += 5
```


The figure below shows two programs that each attempt to convert any negative numbers in a list to 0. The program on the right is incorrect, demonstrating a common logic error.

Figure 8.7.2: Modifying a list during iteration example: Converting negative values to 0.

Correct way to modify the list.

```
user_input = input('Enter
numbers: ')

tokens = user_input.split()

# Convert strings to
integers
nums = []
for token in tokens:
    nums.append(int(token))

# Print each position and
number
print()
for pos, val in
enumerate(nums):

    print(f'{pos}: {val}')

# Change negative values to
0
for pos in range(len(nums)):
    if nums[pos] < 0:
        nums[pos] = 0

# Print new numbers
print('New numbers: ')
for num in nums:
    print(num, end=' ')
```

Incorrect way: list not modified.

```
user_input = input('Enter numbers:')

tokens = user_input.split()

# Convert strings to integers
nums = []
for token in tokens:
    nums.append(int(token))

# Print each position and number
print()
for pos, val in enumerate(nums):

    print(f'{pos}: {val}')

# Change negative values to 0
for num in nums:
    if num < 0:
        num = 0  # Logic error: temp
variable num set to 0

# Print new numbers
print('New numbers: ')
for num in nums:
    print(num, end=' ')
```

```
Enter numbers:5 67 -5 -4 5 6 6 4
0: 5
1: 67
2: -5
3: -4
4: 5
5: 6
6: 6
7: 4
New numbers:
5 67 0 0 5 6 6 4
```

```
Enter numbers:5 67 -5 -4 5 6 6 4
0: 5
1: 67
2: -5
3: -4
4: 5
5: 6
6: 6
7: 4
New numbers:
5 67 -5 -4 5 6 6 4
```


The program on the right illustrates a common logic error. *A common error when modifying a list during iteration is to update the loop variable instead of the list object.* The statement `num = 0` simply binds the name num to the integer literal value 0. The reference in the list is never changed.

In contrast, the program on the left correctly uses an index operation `nums[pos] = 0` to modify to 0 the reference held by the list in position pos. The below activities demonstrate further. Only the second program changes the list's values.

CHALLENGE ACTIVITY 8.7.1: Iterating through a list using range().

566436.4601014.qx3zqy7

Start

Type the program's output

```
user_values = [1, 6, 9]

for n in range(len(user_values)):
   print(user_values[n])
```

1
6
9

1 2 3 4

Check Next

PARTICIPATION ACTIVITY 8.7.1: List modification.

Consider the following program:

```
nums = [10, 20, 30, 40, 50]

for pos in range(len(nums)):
    tmp = nums[pos] / 2
    if (tmp % 2) == 0:
        nums[pos] = tmp
```

1) What's the final value of nums[1]?

Check Show answer

Changing list size

A common error is to add or remove a list element while iterating over that list. Such list modification can lead to unexpected behavior if the programmer is not careful. Ex: Consider the following program that reads in two sets of numbers and attempts to find numbers in the first set that are not in the second set.

Figure 8.7.3: Modifying lists while iterating: Incorrect program.

```
nums1 = []
nums2 = []

user_input = input('Enter first set of
numbers: ')
tokens = user_input.split()  # Split into
separate strings

# Convert strings to integers
print()
for pos, val in enumerate(tokens):
    nums1.append(int(val))
    print(f'{pos}: {val}')

user_input = input('Enter second set of
numbers:')
tokens = user_input.split()

# Convert strings to integers
print()
for pos, val in enumerate(tokens):
    nums2.append(int(val))
    print(f'{pos}: {val}')

# Remove elements from nums1 if also in nums2
print()
for val in nums1:
    if val in nums2:
        print(f'Deleting {val}')
        nums1.remove(val)

# Print new numbers
print('\nNumbers only in first set:', end='
')
for num in nums1:
    print(num, end=' ')
```



```
Enter first set of numbers:5
10 15 20
0: 5
1: 10
2: 15
3: 20
Enter second set of
numbers:15 20 25 30
0: 15
1: 20
2: 25
3: 30

Deleting 15

Numbers only in first set: 5
10 20
```

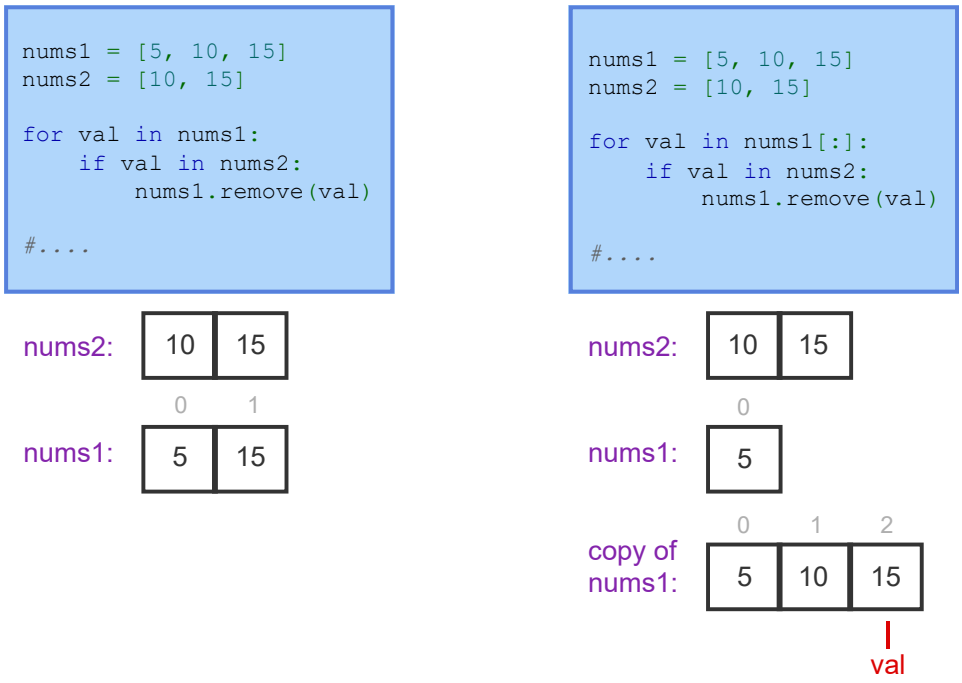
The above example iterates over the list nums1, deleting an element from the list if the element is also found in the list nums2. The programmer expected a certain result, namely that after removing an element from the list, the next iteration of the loop would reference the next element as normal. However, removing the element shifts the position of each following element in the list to the left by one. In the example above, removing 15 from nums1 shifts the value 20 left into position 2. The loop, having just iterated over position 2 and removing 15, moves to the next position and finds the end of the list, thus never evaluating the final value 20.

The problem illustrated by the example above has a simple fix: Iterate over a copy of the list instead of the actual list being modified. Copying the list allows a programmer to modify, swap, add, or delete elements without affecting the loop iterations. The easiest way to copy the iterating list is to use slice notation inside of the loop expression, as in the example below.

Figure 8.7.4: Copy a list using [:].

```
for item in
my_list[:]:
    # Loop
statements.
```


PARTICIPATION ACTIVITY 8.7.2: List modification.



Animation content:

Static Figure:
Begin Python code:
nums1 = [5, 10, 15]
nums2 = [10, 15]

for val in nums1:
  if val in nums2:
    nums1.remove(val)
End Python code.

Step 1: The loop, having just iterated over position 1 and removing 10, moves to the next position and finds the end of the list, thus never evaluating the final value 15.

The program's for loop iterates through each val in nums1: [5, 10, 15]. Within the for loop, the if statement checks to see if the current val is in nums2: [10, 15]. If the current val is in nums2, the value is removed from nums1.

Index 0 of nums1 contains 5, which is not in nums2.

Index 1 of nums1 contains 10, which is in nums2. Thus, 10 is removed from nums1 and nums1 is now [5, 15].

Since nums1 now has only two elements, there is no index 2, thus the for loop terminates.

Step 2: The problem illustrated by the example above can be fixed by iterating over a copy of the list instead of the actual list being modified.

The program's for loop statement, for val in nums1, is changed to for val in nums1[:]. Thus, the program's for loop now iterates through each val in a copy of nums1: [5, 10, 15].

Index 0 of the copy of nums1 contains 5, which is not in nums2.

Index 1 of the copy of nums1 contains 10, which is in nums2. Thus, 10 is removed from nums1 and nums1 is now [5, 15].

Index 2 of the copy of nums1 contains 15, which is in nums2. Thus, 15 is removed from nums1 and nums1 is now [5].

Animation captions:

1. The loop, having just iterated over position 1 and removing 10, moves to the next position and finds the end of the list, thus never evaluating the final value 15.
2. The problem illustrated by the example above can be fixed by iterating over a copy of the list instead of the actual list being modified.

zyDE 8.7.1: Modify the above program to work correctly.

Modify the program (copied from above) using slice notation to iterate over a copy of the list.

Load default template...

```
1
```

```
5 10 15 20
15 20 25 30
```

```
nums1 = []
nums2 = []

user_input = input('Enter
tokens = user_input.split(

# Convert strings to integ
print()
for pos, val in enumerate(
    nums1.append(int(val))

    print(f'{pos}: {val}')

user_input = input('Enter
tokens = user_input.split(
```

Run

PARTICIPATION ACTIVITY 8.7.3: Modifying a list while iterating.

1) Iterating over a list and deleting elements from the original list might cause a logic program error.
   - True
   - False

2) A programmer can iterate over a copy of a list to safely make changes to the original list.
   - True
   - False

CHALLENGE ACTIVITY 8.7.2: Loops modifying lists.

566436.4601014.qx3zqy7

Start

List colony_sizes contains integers read from input. Each integer represents a measurement of bacteria centimeters. Write a loop to update each element in colony_sizes with the element's value multipled by

▶ **Click here for example**

```
colony_sizes = []

tokens = input().split()
for token in tokens:
```

```
    colony_sizes.append(int(token))

print('Values in centimeters:', end=' ')
for measurement in colony_sizes:
    print(measurement, end=' ')
print()

''' Your code goes here '''

print('Values in millimeters:', end=' ')
for measurement in colony_sizes:
    print(measurement, end=' ')
print()
```


1 2

Check Next level

8.8 List comprehensions

A programmer modifies every element of a list in the same way, such as adding 10 to every element. The Python language provides a convenient construct, known as ***list comprehension***, that iterates over a list, modifies each element, and returns a new list of the modified elements.

A list comprehension construct has the following form:

Construct 8.8.1: List comprehension.

```
new_list = [expression for loop_variable_name in
iterable]
```


A list comprehension has three components:

1. An *expression component* to evaluate for each element in the iterable object.
2. A *loop variable component* to bind to the current iteration element.
3. An *iterable object component* to iterate over (list, string, tuple, enumerate, etc).

A list comprehension is always surrounded by brackets, which is a helpful reminder that the comprehension builds and returns a new list object. The loop variable and iterable object components make up a normal for loop expression. The for loop iterates through the iterable object as normal, and

the expression operates on the loop variable in each iteration. The result is a new list containing the values modified by the expression. The program below demonstrates a simple list comprehension that increments each value in a list by 5.

Figure 8.8.1: List comprehension example: A first look.


```
my_list = [10, 20, 30]
list_plus_5 = [(i + 5) for i in
my_list]

print(f'New list contains:
{list_plus_5}')
```

```
New list contains: [15, 25,
35]
```

The following animation illustrates:

PARTICIPATION ACTIVITY 8.8.1: List comprehension.

```
my_list = [50, 23, -4]
my_list_minus10 = [(i - 10) for i in my_list]
```

my_list: | 50 | 23 | -4 |

my_list_minus10: | 40 | 13 | -14 |

Animation content:

Static figure:
Begin Python code:
my_list = [50, 23, -4]
my_list_minus10 = [(i - 10) for i in my_list]
End Python code.

Step 1: My list is created and holds integer values. my_list contains [50, 23, -4].

Step 2: Loop variable i set to each element of my_list.

The for loop iterates through each value of my_list. Within the for loop, 10 is subtracted from the value, and the result is appended to the new list, my_list_minus10.

The first value of my_list is 50, and 50 minus 10 is 40. The second value of my_list is 23, and 23 minus 10 is 13. The third and final value of my_list is negative 4, and negative 4 minus 10 is negative 14. The for loop terminates and my_list_minus10 contains [40, 13, -14].

Animation captions:

1. My list is created and holds integer values.
2. Loop variable i set to each element of my_list.

Programmers commonly prefer using a list comprehension rather than a for loop in many situations. Such preference is due to less code and more efficient execution by the interpreter. The table below shows various for loops and equivalent list comprehensions.

Table 8.8.1: List comprehensions can replace some for loops.

Num	Description	For loop	Equivalent list comprehension	Output of both prog

1	Add 10 to every element.	`my_list = [5, 20, 50]`
		`for i in range(len(my_list)):`
		`  my_list[ i ] += 10`
		`print(my_list)`
			`my_list = [5, 20, 50]`
			`my_list = [(i+10) for i in my_list]`
			`print(my_list)`
				`[15, 30, 60]`

2	Convert every element to a string.	`my_list = [5, 20, 50]`
		`for i in range(len(my_list)):`
		`  my_list[ i ] = str(my_list[ i ])`
		`print(my_list)`
			`my_list = [5, 20, 50]`
			`my_list = [str(i) for i in my_list]`
			`print(my_list)`
				`['5', '20', '50`

3	Convert user input to a list of integers.	`inp = input('Enter numbers:')`
		`my_list = []`
		`for i in inp.split():`
		
		`my_list.append(int(i))`
		`print(my_list)`
			`inp = input('Enter numbers:')`
			`my_list = [int(i) for i in inp.split()]`
			`print(my_list)`
				`Enter numbers: [7, 9, 3]`

4	Find the sum of each row in a two-dimensional list.	`my_list = [[5, 10, 15], [2, 3, 16], [100]]`
		`sum_list = []`
		`for row in my_list:`
		
		`sum_list.append(sum(row))`
		`print(sum_list)`
			`my_list = [[5, 10, 15], [2, 3, 16], [100]]`
			`sum_list = [sum(row) for row in my_list]`
			`print(sum_list)`
				`[30, 21, 100]`

5	Find the sum of the row with the smallest sum in a two-dimensional table.	`my_list = [[5, 10, 15], [2, 3, 16], [100]]`
		`sum_list = []`
		`for row in my_list:`
		
		`sum_list.append(sum(row))`
		`min_row = min(sum_list)`
		`print(min_row)`
			`my_list = [[5, 10, 15], [2, 3, 16], [100]]`
			`min_row = min([sum(row) for row in my_list])`
			`print(min_row)`
				`21`

Note that list comprehension is not an exact replacement of for loops, because list comprehensions create a *new* list object, whereas the typical for loop modifies an existing list.

The third row of the table above has an expression in place of the iterable object component of the list comprehension, `inp.split()`. That expression is evaluated first, and the list comprehension will loop over the list returned by the split().

The last example from above is interesting because the list comprehension is wrapped by the built-in function min(). List comprehension builds a new list when evaluated, so using the new list as an argument to min() is allowed — conceptually the interpreter is just evaluating the more familiar code: min([30, 21, 100]).

PARTICIPATION ACTIVITY 8.8.2: List comprehension examples.

For the following questions, refer to the table above.

1) What's the output of the list comprehension program in row 1 if my_list is [-5, -4, -3]?

Check Show answer

2) Alter the list comprehension from row 2 to convert each number to a float instead of a string.

```
my_list = [5, 20, 50]
my_list = [
for i in my_list]
print(my_list)
```

Check Show answer

3) What's the output of the list comprehension program from row 3 if the user enters "4 6 100"?

Check Show answer

4) What's the output of the list comprehension program in row 4 if my_list is [[5, 10], [1]]?

Check Show answer

5) Alter the list comprehension from row 5 to calculate the sum of every number contained by my_list.

```
 my_list = [[5, 10, 15], [2, 3,
16], [100]]
sum_list  =
([sum(row)
for row in my_list])
print(sum_list)
```

Check Show answer

PARTICIPATION ACTIVITY 8.8.3: Building list comprehensions.

Write a list comprehension that contains elements with the desired values. Use the name "i" as the loop variable.

1) Desired result: twice the value of each element in the list variable x.

Check Show answer

2) Desired result: the absolute value of each element in x. Use the abs() function to find the absolute value of a number.

Check Show answer

3) Desired result: the largest square root of any element in x. Use math.sqrt() to calculate the square root.

Check Show answer

Conditional list comprehensions

A list comprehension can be extended with an optional conditional clause that causes the statement to return a list with only certain elements.

Construct 8.8.2: Conditional list comprehensions.

```
new_list = [expression for name in iterable if
condition]
```


Using the above syntax will only add an element to the resulting list if the condition evaluates to True. The following program demonstrates list comprehension with a conditional clause that returns a list with only even numbers.

Figure 8.8.2: Conditional list comprehension example: Return a list of even numbers.

```
# Get a list of integers from the user
numbers = [int(i) for i in input('Enter
numbers:').split()]

# Return a list of only even numbers
even_numbers = [i for i in numbers if (i % 2) ==
0]
print(f'Even numbers only: {even_numbers}')
```

```
Enter numbers: 5 52 16 7
25
Even numbers only: [52,
16]
....
Enter numbers: 8 12 -14 9
0
Even numbers only: [8, 12,
-14, 0]
```


PARTICIPATION ACTIVITY 8.8.4: Building list comprehensions with conditions.

Write a list comprehension that contains elements with the desired values. Use the name "i" as the loop variable. Use parentheses around the expression or condition as necessary.

1) Only negative values from the list x

```
numbers =
```

Check Show answer

2) Only negative odd values from the list x

```
numbers =
```

Check Show answer

CHALLENGE ACTIVITY 8.8.1: Enter the list comprehension's output.

566436.4601014.qx3zqy7

Start

Type the program's output

```
my_list = [-1, 0, 1, 2]
new_list = [ number + 4 for number in my_list ]
print(new_list)
```

```
[3, 4, 5, 6]
```

1 2 3

Check Next

CHALLENGE ACTIVITY 8.8.2: List comprehensions.

566436.4601014.qx3zqy7

Start

List input_list contains integers read from input. Assign processed_list with a new list where each elem corresponding element in input_list plus one.

▶ **Click here for example**

```
1  input_list = []
2
3  # Read input
4  tokens = input().split()
5  for token in tokens:
6      input_list.append(int(token))
7
8  processed_list = # Your code goes here
9
10 print(f'Original: {input_list}')
11 print(f'Processed: {processed_list}')
```

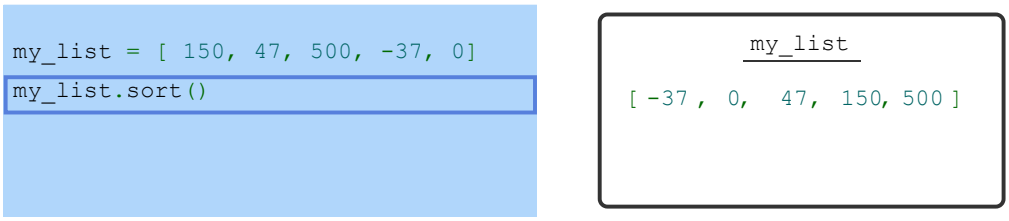
1 2 3 4

Check Next level

8.9 Sorting lists

One of the most useful list methods is ***sort()***, which performs an in-place rearranging of the list elements, sorting the elements from lowest to highest. The normal relational equality rules are followed: numbers compare their values, strings compare ASCII/Unicode encoded values, lists compare element-by-element, etc. The following animation illustrates.

PARTICIPATION ACTIVITY 8.9.1: Sorting a list using list.sort().



Animation content:

Static Figure:
Begin Python code:
my_list = [150, 47, 500, -37, 0]
my_list.sort()
End Python code.

Step 1: The list my_list is created and holds integer values. my_list is [150, 47, 500, -37, 0].

Step 2: The list is sorted in-place. my_list.sort() sorts the values of my_list from least to greatest. Thus, my_list is updated to [-37, 0, 47, 150, 500].

Animation captions:

1. The list my_list is created and holds integer values.
2. The list is sorted in-place.

The sort() method performs element-by-element comparison to determine the final ordering. Numeric type elements like int and float have their values directly compared to determine relative ordering, i.e., 5 is less than 10.

The below program illustrates the basic usage of the list.sort() method, reading book titles into a list and sorting the list alphabetically.

Figure 8.9.1: list.sort() method example: Alphabetically sorting book titles.


```
books = []
prompt = 'Enter new book: '
user_input = input(prompt).strip()

while (user_input.lower() !=
'exit'):
    books.append(user_input)
    user_input =
input(prompt).strip()

books.sort()

print('\nAlphabetical order:')
for book in books:
    print(book)
```

```
Enter new book: Pride, Prejudice, and
Zombies
Enter new book: Programming in Python
Enter new book: Hackers and Painters
Enter new book: World War Z
Enter new book: exit

Alphabetical order:
Hackers and Painters
Pride, Prejudice, and Zombies
Programming in Python
World War Z
```

The sort() method performs in-place modification of a list. Following execution of the statement my_list.sort(), the contents of my_list are rearranged. The ***sorted()*** built-in function provides the same sorting functionality as the list.sort() method, however, sorted() creates and returns a new list instead of modifying an existing list.

Figure 8.9.2: Using sorted() to create a new sorted list from an existing list without modifying the existing list.


```
numbers = [int(i) for i in input('Enter
numbers: ').split()]

sorted_numbers = sorted(numbers)

print(f'\nOriginal numbers: {numbers}')
print(f'Sorted numbers: {sorted_numbers}')
```

```
Enter numbers: -5 5 -100 23 4
5
Original numbers: [-5, 5,
-100, 23, 4, 5]
Sorted numbers: [-100, -5, 4,
5, 5, 23]
```

PARTICIPATION ACTIVITY 8.9.2: list.sort() and sorted().

1) The sort() method modifies a list in place.

- True
- False

2) The output of the following is [13, 7, 5]:

```
primes = [5, 13, 7]
primes.sort()
print(primes)
```

- True
- False

3) The output of `print(sorted([-5, 5, 2]))` is [2, -5, 5].

- True
- False

Both the list.sort() method and the built-in sorted() function have an optional ***key*** argument. The key specifies a function to be applied to each element prior to being compared. Examples of key functions are the string methods str.lower, str.upper, or str.capitalize.

Consider the following example, in which a roster of names is sorted alphabetically. If a name is mistakenly uncapitalized, then the sort algorithm places the name at the end of the list, because lower-case letters have a larger encoded value than upper-case letters. Ex: 'a' maps to the ASCII decimal value of 97 and 'A' maps to 65. Specifying the key function as str.lower (note the absence of parentheses) automatically converts the elements to lower-case before comparison, thus placing the lower-case name at the appropriate position in the sorted list.

Figure 8.9.3: Using the key argument.

```
names = []
prompt = 'Enter name: '

user_input = input(prompt)

while user_input != 'exit':
    names.append(user_input)
    user_input = input(prompt)

no_key_sort = sorted(names)
key_sort = sorted(names, key=str.lower)

print(f'Sorting without key: {no_key_sort}')
print(f'Sorting with key:  {key_sort}')
```



```
Enter name: Serena Williams
Enter name: Venus Williams
Enter name: rafael Nadal
Enter name: john McEnroe
Enter name: exit
Sorting without key: ['Serena Williams', 'Venus Williams', 'john McEnroe', 'rafael
Nadal']
Sorting with key:  ['john McEnroe', 'rafael Nadal', 'Serena Williams', 'Venus
Williams']
```

The key argument can be assigned any function, not just string methods like str.upper and str.lower. Ex: A programmer might want to sort a two-dimensional list by the max of the rows, which can be accomplished by assigning key with the built-in function max, as in sorted(x, key=max).

Figure 8.9.4: The key argument to list.sort() or sorted() can be assigned any function.

```
my_list = [[25], [15, 25, 35], [10,
15]]

sorted_list = sorted(my_list,
key=max)

print(f'Sorted list: {sorted_list}')
```

```
Sorted list: [[10, 15], [25], [15, 25,
35]]
```


Sorting also supports the ***reverse*** argument. The reverse argument can be set to a Boolean value, either True or False. Setting reverse=True flips the sorting from lowest-to-highest to highest-to-lowest. Thus,

the statement `sorted([15, 20, 25], reverse=True)` produces a list with the elements [25, 20, 15].

PARTICIPATION ACTIVITY 8.9.3: Sorting.

Provide an expression using x.sort that sorts the list x accordingly.

1) Sort the elements of x so the greatest element is in position 0.

Check Show answer

2) Arrange the elements of x from lowest to highest, comparing the upper-case variant of each element in the list.

Check Show answer

8.10 Command-line arguments

Command-line arguments are values entered by a user when running a program from a command line. A command line exists in some program execution environments in which a user can run a program by typing at a command prompt. Ex: To run a Python program named "myprog.py" with an argument specifying the location of a file named "myfile1.txt", the user enters the following at the command prompt:

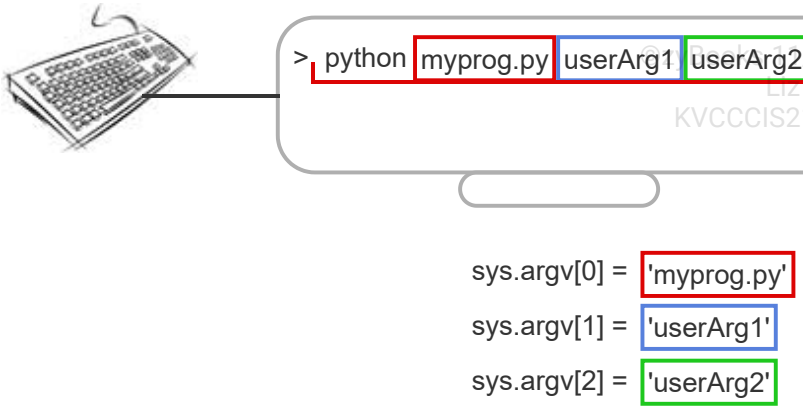
```
> python myprog.py myfile1.txt
```

The contents of this command line are automatically stored in the list ***sys.argv***, which is stored in the standard library sys module. sys.argv consists of one string element for each argument typed on the command line.

When executing a program, the interpreter parses the entire command line to find all sequences of characters separated by whitespace, storing each as a string within the list variable argv. As the entire command line is passed to the program, the name of the program executable is always added as the first element of the list. Ex: For a command line of `python myprog.py myfile1.txt`, argv has the contents ['myprog.py', 'myfile1.txt'].

The following animation further illustrates.

PARTICIPATION ACTIVITY 8.10.1: Command-line arguments.



Animation content:

Static figure: A computer keyboard and a command-line are displayed.

The following text is displayed in the command-line:
> python myprog.py userArg1 userArg2

Step 1: Whitespace separates arguments. Thus, 'myprog.py' is stored at index 0, 'userArg1' is stored at index 1, and 'userArg2' is stored at index 2.

Step 2: User text is stored in sys.argv list.

sys.argv[0] = 'myprog.py'
sys.argv[1] = 'userArg1'
sys.argv[2] = 'userArg2'

Animation captions:

1. Whitespace separates arguments.
2. User text is stored in sys.argv list.

The following program illustrates a simple use of command-line arguments, where the program name is myprog, and two additional arguments should be passed to the program.

Figure 8.10.1: Simple use of command line arguments.

```
import sys

name = sys.argv[1]
age = int(sys.argv[2])

print(f'Hello {name}.')
print(f'{age} is a great
age.\n')
```

```
> python myprog.py Tricia 12
Hello Tricia.
12 is a great age.

> python myprog.py Aisha 30
Hello Aisha.
30 is a great age.

> python myprog.py Franco
Traceback (most recent call last):
  File "myprog.py", line 4, in
<module>
    age = sys.argv[2]
IndexError: list index out of range
```


While a program may expect the user to enter certain command-line arguments, there is no guarantee that the user will do so. *A common error is to access elements within argv without first checking the length of argv to ensure the user entered enough arguments, resulting in an IndexError being generated.* In the last example above, the user did not enter the age argument, resulting in an IndexError when accessing argv. Conversely, if a user enters too many arguments, extra arguments will be ignored. Above, if the user typed `python myprog.py Alan 70 pizza`, "pizza" will be stored in argv[3] but never used by the program.

Thus, when a program uses command-line arguments, a good practice is to always check the length of argv at the beginning of the program to ensure that the user entered the correct number of arguments. The following program uses the statement `if len(sys.argv) != 3` to check for the correct number of arguments, the three arguments being the program, name, and age. If the number of arguments is incorrect, the program prints an error message, referred to as a ***usage message***, that provides the user with an example of the correct command-line argument format. *A good practice is to always output a usage message when the user enters incorrect command-line arguments.*

Figure 8.10.2: Checking for proper number of command-line arguments.

```
import sys

if len(sys.argv) != 3:
    print('Usage: python myprog.py name age\n')
    sys.exit(1)  # Exit the program, indicating
an error with 1.

name = sys.argv[1]
age = int(sys.argv[2])

print(f'Hello {name}. ')
print(f'{age} is a great age.\n')
```

```
> python myprog.exe
Tricia 12
Hello Tricia. 12 is a
great age.

> python myprog.py Franco
Usage: python myprog.py
name age

> python myprog.py Alan
70 pizza
Usage: python myprog.py
name age
```


Note that all command-line arguments in argv are strings. If an argument represents a different type like a number, then the argument needs to be converted using one of the built-in functions such as int() or float().

A single command-line argument may need to include a space. Ex: A person's name might be "Mary Jane". Recall that whitespace characters are used to separate the character typed on the command line into the arguments for the program. If the user provided a command line of `python myprog.py Mary Jane 65`, the command-line arguments would consist of four arguments: "myprog.py", "Mary", "Jane", and "65". When a single argument needs to contain a space, the user can enclose the argument within quotes "" on the command line, such as the following, which will result in only three command-line arguments, where sys.argv has the contents ['myprog.py', 'Mary Jane', '65'].

```
> python myprog.py "Mary Jane" 65
```

PARTICIPATION ACTIVITY 8.10.2: Command-line arguments.

1) What is the value of sys.argv[1] given the following command-line input (include quotes in your answer)? `python prog.py Tricia Miller 26`

Check Show answer

2) What is the value of sys.argv[1] given the following command-line input (include quotes in your

answer): `python prog.py 'Tricia Miller' 26`

Check Show answer

Exploring further:

Command-line arguments can become quite complicated for large programs with many options. There are entire modules of the standard library dedicated to aiding a programmer develop sophisticated argument parsing strategies. The reader is encouraged to explore modules such as argparse and getopt.

- argparse: Parser for command-line options, arguments, and sub-commands
- getopt: C-style parser for command-line options

8.11 Additional practice: Engineering examples

The following is a sample programming lab activity. Not all classes using a zyBook require students to fully complete this activity. No auto-checking is performed. Users planning to fully complete this program may consider first developing their code in a separate programming environment.

A list can be useful in solving various engineering problems. One problem is computing the voltage drop across a series of resistors. If the total voltage across the resistors is V, then the current through the resistors will be I = V/R, where R is the sum of the resistances. The voltage drop Vx across resistor x is then Vx = I · Rx.

zyDE 8.11.1: Calculate voltage drops across series of resistors.

The following program uses a list to store a user-entered set of resistance values and computes I.

Modify the program to compute the voltage drop across each resistor, store each in another list (voltage_drop), and print the results in the following format:

```
5 resistors are in series.
This program calculates the voltage drop across each resistor.
Input voltage applied to circuit: 12.0
Input ohms of 5 resistors
1) 3.3
2) 1.5
3) 2.0
4) 4.0
5) 2.2
Voltage drop per resistor is
1) 3.0 V
2) 1.4 V
3) 1.8 V
4) 3.7 V
5) 2.0 V
```


Load default template...

```
1  num_resistors = 5
2  resistors = []
3  voltage_drop = []
4
5
6  print(f'{num_resistors} resistors are in the series.')
7  print('This program calculates the'),
8  print('voltage drop across each resistor.')
9
10 input_voltage = float(input('Input voltage applied to circ
11 print (input_voltage)
12
13
14 print(f'Input ohms of {num_resistors} resistors')
15 for i in range(num_resistors):
16
17     res = float(input(f'{i + 1}) '))
18     print(res)
```

```
12
3.3
1.5
```

Run

Engineering problems commonly involve matrix representation and manipulation. A matrix can be captured using a two-dimensional list. Then matrix operations can be defined on such lists.

zyDE 8.11.2: Matrix multiplication of 4x2 and 2x3 matrices.

The following illustrates matrix multiplication for 4x2 and 2x3 matrices captured as two-dimensional lists.

Run the program below. Try changing the size and value of the matrices and computing new values.

Load default template...

```
m1_rows = 4
m1_cols = 2
m2_rows = m1_cols  # Must have same value
m2_cols = 3

m1 = [
    [3, 4],
    [2, 3],
    [1, 2],
    [0, 2]
]

m2 = [
    [5, 4, 4],
    [0, 2, 3]
]

m3 = [
```


Run

8.12 Dictionaries

A dictionary is another type of container object that is different from sequences such as strings, tuples, and lists. Dictionaries contain references to objects as key-value pairs — each key in the dictionary is associated with a value, much like each word in an English language dictionary is associated with a definition. As of Python 3.7, dictionary elements maintain their insertion order. The ***dict*** type implements a dictionary in Python.

PARTICIPATION ACTIVITY 8.12.1: Dictionaries.

Word	Definition
'cat'	'A small....'
'car'	'....'

```
my_dict = {
    'Bobby': 'A+',
```

Key	Value
'Bobby'	'A+'
'Alan'	67

'cave' '....'

```
{
    'Alan': 67,
    10: 5.0
}
```

10 5.0

my_dict['Alan'] 67

Animation content:

Step 1: An English dictionary associates words with definitions.

Word	Definition
'cat'	'A small, feline carnivore.'
'car'	'....'
'cave'	'...'

Static figure:
Being Python code:

```
my_dict = {
   'Bobby': 'A+',
   'Alan': 67,
   10: 5.0
}
```

End Python code.

Step 2: A Python dictionary associates keys with values. For example, if the key is 'Alan', the corresponding value in my_dict is 67. Thus, my_dict['Alan'] returns 67.

Table summary of key-value pairs for the dictionary my_dict.

Key	Value
'Bobby'	'A+'
'Alan'	67

10	5.0

Animation captions:

1. An English dictionary associates words with definitions.
2. A Python dictionary associates keys with values.

There are several approaches to create a dict:

- The first approach wraps braces { } around key-value pairs of literals and/or variables: `{'Jose': 'A+', 'Gino': 'C-'}` creates a dictionary with two keys, 'Jose' and 'Gino', that are associated with the grades 'A+' and 'C-', respectively.
- The second approach uses ***dictionary comprehension***, which evaluates a loop to create a new dictionary, similar to how list comprehension creates a new list. Dictionary comprehension is out of scope for this material.
- Other approaches use the ***dict()*** built-in function, using either keyword arguments to specify the key-value pairs or by specifying a list of tuple pairs. The following creates equivalent dictionaries:
  - `dict(Bobby='805-555-2232', Johnny='951-555-0055')`
  - `dict([('Bobby', '805-555-2232'), ('Johnny', '951-555-0055')])`

In practice, a programmer first creates a dictionary and then adds entries, perhaps by reading user input or text from a file. Dictionaries are mutable, so entries can be added, modified, or removed in place. The table below shows some common dict operations.

Table 8.12.1: Common dict operations.

Operation	Description	Example code
my_dict[key]	Indexing operation — retrieves the value associated with key.	`jose_grade = my_dict['Jose']`
my_dict[key] = value	Adds an entry if the entry does not exist, else modifies the existing entry.	`my_dict['Jose'] = 'B+'`
del my_dict[key]	Deletes the key from a dict.	`del my_dict['Jose']`
key in my_dict	Tests for existence of key in my_dict.	`if 'Jose' in my_dict: # ....`

Dictionaries can contain objects of arbitrary type, even other containers such as lists and nested dictionaries. Ex: `my_dict['Jason'] = ['B+', 'A-']` creates an entry in my_dict whose value is a list containing the grades of the student 'Jason'.

zyDE 8.12.1: Dictionary example: Gradebook.

The following program implements a gradebook. The student_grades dictionary consists of entries whose keys are student names and whose values are lists of student scores. Modify the inputs to change the dictionary.

Load default template...

```
student_grades = {}  # Create an empty dict
grade_prompt = "Enter name and grade (Ex. 'Bob A+'):"
del_prompt = "Enter a name to delete:"
menu_prompt = ("1. Add/modify student grade\n"
               "2. Delete student grade\n"
               "3. Print student grades\n"
               "4. Quit\n")

while True:  # Exit when user enters no input
    command = input(menu_prompt).lower().strip()
    if command == '1':
        name, grade = input(grade_prompt).split()
        student_grades[name] = grade
    elif command == '2':
        name = input(del_prompt)
        del student_grades[name]
    elif command == '3':
        print(student_grades)
```

```
1
Bob A+
1
```

Run

PARTICIPATION ACTIVITY 8.12.2: Dictionaries.

1) Dictionary entries can be modified in place. A new dictionary does not need to be created every time an element is added, changed, or removed.

- True
- False

2) The variable my_dict created with the following code contains two keys: 'Bob' and 'A+'.

```
my_dict = dict(name='Bob',
grade='A+')
```

- True
- False

CHALLENGE ACTIVITY 8.12.1: Enter the output of dictionaries.

566436.4601014.qx3zqy7

Start

Type the program's output

```
airport_codes = {}
airport_codes['Minneapolis'] = 'MSP'
airport_codes['Atlanta'] = 'ATL'
airport_codes['Seattle'] = 'SEA'

print(airport_codes['Minneapolis'])
print(airport_codes['Atlanta'])
```

```
MSP
ATL
```

1 2 3

Check Next

CHALLENGE ACTIVITY 8.12.2: Dictionaries.

566436.4601014.qx3zqy7

Start

Perform the following tasks:

- Create a dictionary named person_dict containing key-value pairs 'first_name': 'Huy', 'last_name': '
  'birthday': '03/11'.
- Read strings new_key and new_value from input.
- Add new_key and new_value as a new key-value pair to person_dict with new_key as the key and

▶ **Click here to show example**

```
''' Your code goes here '''

print(f'first_name: {person_dict["first_name"]}')
print(f'last_name: {person_dict["last_name"]}')
print(f'birthday: {person_dict["birthday"]}')
print(f'{new_key}: {person_dict[new_key]}')
```


1 2 3

Check Next level

8.13 Dictionary methods

A ***dictionary method*** is a function provided by the dictionary type (dict) that operates on a specific dictionary object. Dictionary methods can perform useful operations, such as adding or removing elements, obtaining all the keys or values in the dictionary, merging dictionaries, etc.

Below is a list of common dictionary methods:

Table 8.13.1: Dictionary methods.

Dictionary method	Description	Code example	Out

my_dict.clear()	Removes all items from the dictionary.	`my_dict = {'Ahmad': 1, 'Jane': 42}`
		`my_dict.clear()`
		`print(my_dict)`
			{}

my_dict.get(key, default)	Reads the value of the key from the dictionary. If the key does not exist in the dictionary, then returns default.	`my_dict = {'Ahmad': 1, 'Jane': 42}`
		`print(my_dict.get('Jane', 'N/A'))`
		`print(my_dict.get('Chad', 'N/A'))`
			`42`
			`N/A`

my_dict1.update(my_dict2)	Merges dictionary my_dict1 with another dictionary my_dict2. Existing entries in my_dict1 are overwritten if the same keys exist in my_dict2.	`my_dict = {'Ahmad': 1, 'Jane': 42}`
		`my_dict.update({'John': 50})`
		`print(my_dict)`
			`{'Ahm`
			`1,`
			`'Jane`
			`42,`
			`'John`
			`50}`

my_dict.pop(key, default)	Removes and returns the key value from the dictionary. If key does not exist, then default is returned.	`my_dict = {'Ahmad': 1, 'Jane': 42}`
		`val = my_dict.pop('Ahmad')`
		`print(my_dict)`
			`{'Jan`
			`42}`

Modification of dictionary elements using the above methods is performed in-place. Ex: Following the evaluation of the statement my_dict.pop('Ahmad'), any other variables that reference the same object as my_dict will also reflect the removal of 'Ahmad'. As with lists, a programmer should be careful not to modify dictionaries without realizing that other references to the objects may be affected.

PARTICIPATION ACTIVITY 8.13.1: Dictionary methods.

Determine the output of each code segment. If the code produces an error, type None.
Assume that my_dict has the following entries:

```
my_dict = dict(bananas=1.59, fries=2.39, burger=3.50, sandwich=2.99)
```

1)
```
my_dict.update(dict(soda=1.49,
burger=3.69))
burger_price =
my_dict.get('burger', 0)
print(burger_price)
```

Check Show answer

2)
```
my_dict['burger'] =
my_dict['sandwich']
val = my_dict.pop('sandwich')
print(my_dict['burger'])
```

Check Show answer

CHALLENGE ACTIVITY 8.13.1: Enter the output of dictionary methods.

566436.4601014.qx3zqy7

Start

Type the program's output

```
airport_codes = {
    'Dallas': 'DAL',
    'Minneapolis': 'MSP',
    'Los Angeles': 'LAX',
    'Cincinnati': 'CVG',
    'Atlanta': 'ATL'
}

print(airport_codes.get('Amsterdam', 'na'))
print(airport_codes.get('New York', 'na'))
print(airport_codes.get('Minneapolis', 'na'))
```

```
na
na
MSP
```


1 2 3

Check Next

CHALLENGE ACTIVITY 8.13.2: Dictionary methods.

566436.4601014.qx3zqy7

Start

Multiple key-value pairs, each representing a person's name and age, are read from input and added to patient_data1 with patient_data2. Then, clear patient_data2.

▶ **Click here for example**

```
patient_data1 = {'Eve': '78'}
patient_data2 = {}
ref_record1 = patient_data1  # For testing purposes, ref_record1 references patient_dat
ref_record2 = patient_data2  # For testing purposes, ref_record2 references patient_dat

input_line = input()
while input_line != 'exit':
    name, age = input_line.split()
    patient_data2[name] = age
    input_line = input()

''' Your code goes here '''

print('Patient data 1:')
print(patient_data1)
print('Patient data 2:')
print(patient_data2)
```


1 2

Check Next level

8.14 Iterating over a dictionary

As usual with containers, a common programming task is to iterate over a dictionary and access or modify the elements of the dictionary. A for loop can be used to iterate over a dictionary object, with the loop variable set to a key of an entry in each iteration. The order in which the keys are iterated over is the order in which the elements were inserted into the dictionary. The Python interpreter creates a hash of each key. A ***hash*** is a transformation of the key into a unique value that allows the interpreter to perform fast lookup. So, the ordering is determined by the hash value, but hash values can change depending on the Python version and other factors.

Construct 8.14.1: A for loop over a dictionary retrieves each key in the dictionary.

```
for key in dictionary:  # Loop expression
    # Statements to execute in the loop

#Statements to execute after the loop
```

The dict type also supports the useful methods items(), keys(), and values() methods, which produce a view object. A ***view object*** provides read-only access to dictionary keys and values. A program can iterate over a view object to access one key-value pair, one key, or one value at a time, depending on the method used. A view object reflects any updates made to a dictionary, even if the dictionary is altered after the view object is created.

- dict.items() – returns a view object that yields (key, value) tuples.
- dict.keys() – returns a view object that yields dictionary keys.
- dict.values() – returns a view object that yields dictionary values.

The following examples show how to iterate over a dictionary using the above methods:

Figure 8.14.1: Iterating over a dictionary.

dict.items()

```
num_calories = dict(Coke=90,
Coke_zero=0, Pepsi=94)
for soda, calories in
num_calories.items():
    print(f'{soda}: {calories}')
```

```
Coke: 90
Coke_zero: 0
Pepsi: 94
```


dict.keys()

```
num_calories = dict(Coke=90,
Coke_zero=0, Pepsi=94)
for soda in num_calories.keys():
    print(soda)
```

```
Coke
Coke_zero
Pepsi
```

dict.values()

```
num_calories = dict(Coke=90,
Coke_zero=0, Pepsi=94)
for calories in
num_calories.values():
    print(calories)
```

```
90
0
94
```

When a program iterates over a view object, one result is generated for each iteration as needed, instead of generating an entire list containing all of the keys or values. Such behavior allows the interpreter to save memory. Since results are generated as needed, view objects do not support indexing. A statement such as my_dict.keys()[0] produces an error. Instead, a valid approach is to use the list() built-in function to convert a view object into a list and then perform the necessary operations. The example below converts a dictionary view into a list, so the list can be sorted to find the two closest planets to Earth.

Figure 8.14.2: Use list() to convert view objects into lists.

```
solar_distances = dict(mars=219.7e6, venus=116.4e6,
jupiter=546e6, pluto=2.95e9)
list_of_distances = list(solar_distances.values())
# Convert view to list

sorted_distance_list = sorted(list_of_distances)
closest = sorted_distance_list[0]
next_closest = sorted_distance_list[1]

print(f'Closest planet is {closest:.4e}')
print(f'Second closest planet is
{next_closest:.4e}')
```



```
Closest planet is
1.1640e+08
Second closest planet
is 2.1970e+08
```

The dict.items() method is particularly useful, as the view object that is returned produces tuples containing the key-value pairs of the dictionary. The key-value pairs can then be unpacked at each iteration, similar to the behavior of enumerate(), providing both the key and the value to the loop body statements without requiring extra code.

zyDE 8.14.1: Iterating over a dictionary example: Gradebook statistics.

Write a program that uses the keys(), values(), and/or items() dict methods to find statistics about the student_grades dictionary. Find the following:

- Print the name and grade percentage of the student with the highest total of points.
- Find the average score of each assignment.
- Find and apply a curve to each student's total score so the best student has 100% of the total points.

Load default template... Run

```
1
2  # student_grades contains sc
3  student_grades = {
4      'Andrew': [56, 79, 90, 2
5      'Nisreen': [88, 62, 68,
6      'Alan': [95, 88, 92, 85,
7      'Chang': [76, 88, 85, 82
8      'Tricia': [99, 92, 95, 8
9  }
10
11
12
```

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Liz Vokac Main
KVCCCIS216JohnsonFall2024

PARTICIPATION ACTIVITY 8.14.1: Iterating over dictionaries.

Fill in the code, using the dict methods items(), keys(), or values() where appropriate.

1) Print each key in the dictionary my_dict.

```
for key in :
    print(key)
```

Check Show answer

2) Change all negative values in my_dict to 0.

```
for key, value in :
    if value < 0:
        my_dict[key] = 0
```

Check Show answer

3) Print twice the value of every value in my_dict.

```
for v in :
    print(2 * v)
```

Check Show answer

CHALLENGE ACTIVITY 8.14.1: Iterating over a dictionary.

566436.4601014.qx3zqy7

Start

Multiple key-value pairs, each representing a person's name and age, are read from input and added to patients_info's items into a list and then sort the list. Assign sorted_items with the sorted list.

▶ **Click here for example**


```
patients_info = {}

input_line = input()
while input_line != 'quit':
    name, age = input_line.split()
    patients_info[name] = int(age)
    input_line = input()

''' Your code goes here '''
```

```
print(sorted_items)
```

1

2

Check Next level

8.15 Dictionary nesting

A dictionary may contain one or more ***nested dictionaries***, in which the dictionary contains another dictionary as a value. Consider the following code:

Figure 8.15.1: Nested dictionaries.

```
students = {}
students ['Jose'] = {'Grade': 'A+', 'StudentID': 22321}

print('Jose:')

print(f' Grade: {students ["Jose"]["Grade"]}')

print(f' ID: {students["Jose"]["StudentID"]}')
```

```
Jose:
 Grade: A+
 ID: 22321
```

The variable students is first created as an empty dictionary. An indexing operation creates a new entry in students with the key 'Jose' and the value of another dictionary. Indexing operations can be applied to the nested dictionary by using consecutive sets of brackets []: The expression `students['Jose']['Grade']` first obtains the value of the key 'Jose' from students, yielding the nested dictionary. The second set of brackets indexes into the nested dictionary, retrieving the value of the key 'Grade'.

Nested dictionaries also serve as a simple but powerful data structure. A ***data structure*** is a method of organizing data in a logical and coherent fashion. Container objects like lists and dicts are already a

form of a data structure, but nesting such containers provides a programmer with much more flexibility in the way that the data can be organized. Consider the simple example below that implements a gradebook using nested dictionaries to organize students and grades.

Figure 8.15.2: Nested dictionaries example: Storing grades.

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```
grades = {
    'John Ponting': {
        'Homeworks': [79, 80, 74],
        'Midterm': 85,
        'Final': 92
    },
    'Jacques Kallis': {
        'Homeworks': [90, 92, 65],
        'Midterm': 87,
        'Final': 75
    },
    'Ricky Bobby': {
        'Homeworks': [50, 52, 78],
        'Midterm': 40,
        'Final': 65
    },
}

user_input = input('Enter student name: ')

while user_input != 'exit':
    if user_input in grades:
        # Get values from nested dict
        homeworks = grades[user_input]
['Homeworks']
        midterm = grades[user_input]['Midterm']
        final = grades[user_input]['Final']

        # print info
        for hw, score in enumerate(homeworks):

            print(f'Homework {hw}: {score}')


        print(f'Midterm: {midterm}')

        print(f'Final: {final}')

        # Compute student total score
        total_points = sum([i for i in homeworks])
+ midterm + final

        print(f'Final percentage: {100*
(total_points / 500.0):.1f}%')

    user_input = input('Enter student name: ')
```



```
Enter student name:
Ricky Bobby
Homework 0: 50
Homework 1: 52
Homework 2: 78
Midterm: 40
Final: 65
Final percentage: 57.0%
....
Enter student name:
John Ponting
Homework 0: 79
Homework 1: 80
Homework 2: 74
Midterm: 85
Final: 92
Final percentage: 82.0%
```

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Note the whitespace and indentation used to lay out the nested dictionaries. Such layout improves the readability of the code and makes the hierarchy of the data structure obvious. The extra whitespace does not affect the dict elements, as the interpreter ignores indentation in a multi-line construct.

A benefit of using nested dictionaries is that the code tends to be more readable, especially if the keys are a category like 'Homeworks'. Alternatives like nested lists tend to require more code, consisting of more loop constructs and variables.

Dictionaries support arbitrary levels of nesting. Ex: The expression `students['Jose']['Homeworks'][2]['Grade']` might be applied to a dictionary that has four levels of nesting.

zyDE 8.15.1: Nested dictionaries example: Music library.

The following example demonstrates a program that uses 3 levels of nested dictionaries to create a simple music library.

The following program uses nested dictionaries to store a small music library. Extend the program so a user can add artists, albums, and songs to the library. First, add a command that adds an artist name to the music dictionary. Then add commands for adding albums and songs. Take care to check that an artist exists in the dictionary before adding an album, and that an album exists before adding a song.

Load default template...

```
1  music = {
2      'Pink Floyd': {
3          'The Dark Side of
4              'songs': [ 'Sp
5              'year': 1973,
6              'platinum': Tr
7          },
8          'The Wall': {
9              'songs': [ 'Ar
10             'year': 1979,
11             'platinum': Tr
12         }
13     },
14     'Justin Bieber': {
15         'My World':{
16             'songs': ['One
17             'year': 2010,
18
```

Pre-enter any input for program, then press run.

Run

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PARTICIPATION ACTIVITY 8.15.1: Nested dictionaries.

1) Nested dictionaries are a flexible way to organize data.

- True

- False

2) Dictionaries can contain, at most, three levels of nesting.

- True
- False

3) The expression `{'D1': {'D2': 'x'}}` is valid.

- True
- False

8.16 LAB: Varied amount of input data

Statistics are often calculated with varying amounts of input data. Write a program that takes any number of non-negative floating-point numbers as input, and outputs the max and average, respectively.

Output the max and average with two digits after the decimal point.

Ex: If the input is:

```
14.25 25 0 5.75
```

the output is:

```
25.00 11.25
```


LAB ACTIVITY 8.16.1: LAB: Varied amount of input data 10 / 10

main.py — Load default template...


```
float_data = input()
tokens = float_data.split()

num_data_items = len(tokens)


float_data_items = [float(i) for i in tokens]
max_datum = max(float_data_items)
sum_data = sum(float_data_items)
data_mean = sum_data / num_data_items

print(f'{max_datum:.2f} {data_mean:.2f}')
```

```
13
```

Develop mode | Submit mode

Run your program as often as you'd like, before submitting for grading. Below, type any needed input values in the first box, then click **Run program** and observe the program's output in the second box.

Enter program input (optional)

```
3.5 4.6 11 23.233333
```

Run program

Input (from above) → main.py (Your program) → Output

Program output displayed here

Coding trail of your work What is this?

```
11/7 R-0-0-10 min:6
```

8.17 LAB: Filter and sort a list

This section's content is not available for print.

8.18 LAB: Elements in a range

Write a program that first gets a list of integers from input. That list is followed by two more integers representing lower and upper bounds of a range. Your program should output all integers from the list that are within that range (inclusive of the bounds).

Ex: If the input is:

```
25 51 0 200 33
0 50
```

the output is:

```
25,0,33,
```


The bounds are 0-50, so 51 and 200 are out of range and thus not output.

For coding simplicity, follow each output integer by a comma, even the last one. Do not end with newline.

LAB ACTIVITY | 8.18.1: LAB: Elements in a range | 10 / 10

main.py — Load default template...

```
user_input1 = input()
user_input_bounds = input()

tokens = user_input1.split()
bounds = user_input_bounds.split()

integers = [int(i) for i in tokens]
int_bounds = [int(i) for i in bounds]

lower_bound = int_bounds[0]
upper_bound = int_bounds[1]

in_range_ints = [int for int in integers if lower_bound <= int <= upper_bound ]

for i in range(len(in_range_ints)):
    print(f'{in_range_ints[i]},',end='')
```

Develop mode | **Submit mode**

Run your program as often as you'd like, before submitting for grading. Below, type any needed input values in the first box, then click **Run program** and observe the program's output in the second box.

Enter program input (optional)

```
25 51 0 200 33
0 50
```

Run program Input (from above) → main.py (Your program) → Output

Program output displayed here

Coding trail of your work What is this?

```
11/7 R--10 min:9
```

8.19 LAB: Contact list

This section's content is not available for print.

8.20 LAB: Car wash

Write a program to calculate the total price for car wash services. A base car wash is $10. A dictionary with each additional service and the corresponding cost has been provided. Two additional services can be selected. A '-' signifies an additional service was not selected. Output all selected services, according to the input order, along with the corresponding costs and then the total price for all car wash services.

Ex: If the input is:

```
Tire shine
Wax
```

the output is:


```
ZyCar Wash
Base car wash - $10
Tire shine - $2
Wax - $3
-----
Total price: $15
```