PYTHON CRASH COURSE

3RD EDITION

A Hands-On, Project-Based Introduction to Programming

by Eric Matthes

no starch
press

San Francisco

First printing

26 25 24 23 22 1 2 3 4 5

ISBN-13: 978-1-7185-0270-3 (print)
ISBN-13: 978-1-7185-0271-0 (ebook)

Publisher: William Pollock
Managing Editor: Jill Franklin
Production Editor: Jennifer Kepler
Developmental Editor: Eva Morrow
Cover Illustrator: Josh Ellingson
Interior Design: Octopod Studios
Technical Reviewer: Kenneth Love
Copyeditor: Doug McNair
Compositor: Jeff Lytle, Happenstance Type-O-Rama
Proofreader: Scout Festa

For information on distribution, bulk sales, corporate sales, or translations, please contact No Starch Press, Inc. directly at info@nostarch.com or:

No Starch Press, Inc.
245 8th Street, San Francisco, CA 94103
phone: 1.415.863.9900
www.nostarch.com

The Library of Congress has catalogued the first edition as follows:

```
Matthes, Eric, 1972-
  Python crash course : a hands-on, project-based introduction to programming / by Eric Matthes.
       pages cm
  Includes index.
  Summary: "A project-based introduction to programming in Python, with exercises. Covers general
programming concepts, Python fundamentals, and problem solving. Includes three projects - how to
create a simple video game, use data visualization techniques to make graphs and charts, and build
an interactive web application"-- Provided by publisher.
  ISBN 978-1-59327-603-4 -- ISBN 1-59327-603-6
 1.  Python (Computer program language)  I. Title.
  QA76.73.P98M38 2015
  005.13'3--dc23
                                                                    2015018135
```

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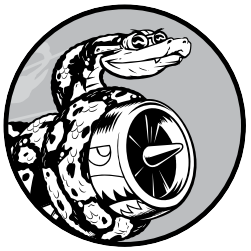
3

INTRODUCING LISTS



In this chapter and the next you'll learn what lists are and how to start working with the elements in a list. Lists allow you to store sets of information in one place, whether you have just a few items or millions of items. Lists are one of Python's most powerful features readily accessible to new programmers, and they tie together many important concepts in programming.

What Is a List?

A *list* is a collection of items in a particular order. You can make a list that includes the letters of the alphabet, the digits from 0 to 9, or the names of all the people in your family. You can put anything you want into a list, and the items in your list don't have to be related in any particular way. Because

a list usually contains more than one element, it's a good idea to make the name of your list plural, such as `letters`, `digits`, or `names`.

In Python, square brackets ([]) indicate a list, and individual elements in the list are separated by commas. Here's a simple example of a list that contains a few kinds of bicycles:

bicycles.py

```
bicycles = ['trek', 'cannondale', 'redline', 'specialized']
print(bicycles)
```

If you ask Python to print a list, Python returns its representation of the list, including the square brackets:

```
['trek', 'cannondale', 'redline', 'specialized']
```

Because this isn't the output you want your users to see, let's learn how to access the individual items in a list.

Accessing Elements in a List

Lists are ordered collections, so you can access any element in a list by telling Python the position, or *index*, of the item desired. To access an element in a list, write the name of the list followed by the index of the item enclosed in square brackets.

For example, let's pull out the first bicycle in the list `bicycles`:

```
bicycles = ['trek', 'cannondale', 'redline', 'specialized']
print(bicycles[0])
```

When we ask for a single item from a list, Python returns just that element without square brackets:

```
trek
```

This is the result you want your users to see: clean, neatly formatted output.

You can also use the string methods from Chapter 2 on any element in this list. For example, you can format the element `'trek'` to look more presentable by using the `title()` method:

```
bicycles = ['trek', 'cannondale', 'redline', 'specialized']
print(bicycles[0].title())
```

This example produces the same output as the preceding example, except `'Trek'` is capitalized.

Index Positions Start at 0, Not 1

Python considers the first item in a list to be at position 0, not position 1. This is true of most programming languages, and the reason has to do with

how the list operations are implemented at a lower level. If you're receiving unexpected results, ask yourself if you're making a simple but common off-by-one error.

The second item in a list has an index of 1. Using this counting system, you can get any element you want from a list by subtracting one from its position in the list. For instance, to access the fourth item in a list, you request the item at index 3.

The following asks for the bicycles at index `1` and index `3`:

```
bicycles = ['trek', 'cannondale', 'redline', 'specialized']
print(bicycles[1])
print(bicycles[3])
```

This code returns the second and fourth bicycles in the list:

```
cannondale
specialized
```

Python has a special syntax for accessing the last element in a list. If you ask for the item at index `-1`, Python always returns the last item in the list:

```
bicycles = ['trek', 'cannondale', 'redline', 'specialized']
print(bicycles[-1])
```

This code returns the value `'specialized'`. This syntax is quite useful, because you'll often want to access the last items in a list without knowing exactly how long the list is. This convention extends to other negative index values as well. The index `-2` returns the second item from the end of the list, the index `-3` returns the third item from the end, and so forth.

Using Individual Values from a List

You can use individual values from a list just as you would any other variable. For example, you can use f-strings to create a message based on a value from a list.

Let's try pulling the first bicycle from the list and composing a message using that value:

```
bicycles = ['trek', 'cannondale', 'redline', 'specialized']
message = f"My first bicycle was a {bicycles[0].title()}."

print(message)
```

We build a sentence using the value at `bicycles[0]` and assign it to the variable `message`. The output is a simple sentence about the first bicycle in the list:

```
My first bicycle was a Trek.
```

TRY IT YOURSELF

Try these short programs to get some firsthand experience with Python's lists. You might want to create a new folder for each chapter's exercises, to keep them organized.

3-1. Names: Store the names of a few of your friends in a list called `names`. Print each person's name by accessing each element in the list, one at a time.

3-2. Greetings: Start with the list you used in Exercise 3-1, but instead of just printing each person's name, print a message to them. The text of each message should be the same, but each message should be personalized with the person's name.

3-3. Your Own List: Think of your favorite mode of transportation, such as a motorcycle or a car, and make a list that stores several examples. Use your list to print a series of statements about these items, such as "I would like to own a Honda motorcycle."

Modifying, Adding, and Removing Elements

Most lists you create will be *dynamic*, meaning you'll build a list and then add and remove elements from it as your program runs its course. For example, you might create a game in which a player has to shoot aliens out of the sky. You could store the initial set of aliens in a list and then remove an alien from the list each time one is shot down. Each time a new alien appears on the screen, you add it to the list. Your list of aliens will increase and decrease in length throughout the course of the game.

Modifying Elements in a List

The syntax for modifying an element is similar to the syntax for accessing an element in a list. To change an element, use the name of the list followed by the index of the element you want to change, and then provide the new value you want that item to have.

For example, say we have a list of motorcycles and the first item in the list is `'honda'`. We can change the value of this first item after the list has been created:

motorcycles.py

```
motorcycles = ['honda', 'yamaha', 'suzuki']
print(motorcycles)

motorcycles[0] = 'ducati'
print(motorcycles)
```

Here we define the list `motorcycles`, with `'honda'` as the first element. Then we change the value of the first item to `'ducati'`. The output shows that the first item has been changed, while the rest of the list stays the same:

```
['honda', 'yamaha', 'suzuki']
['ducati', 'yamaha', 'suzuki']
```

You can change the value of any item in a list, not just the first item.

Adding Elements to a List

You might want to add a new element to a list for many reasons. For example, you might want to make new aliens appear in a game, add new data to a visualization, or add new registered users to a website you've built. Python provides several ways to add new data to existing lists.

Appending Elements to the End of a List

The simplest way to add a new element to a list is to *append* the item to the list. When you append an item to a list, the new element is added to the end of the list. Using the same list we had in the previous example, we'll add the new element `'ducati'` to the end of the list:

```
motorcycles = ['honda', 'yamaha', 'suzuki']
print(motorcycles)

motorcycles.append('ducati')
print(motorcycles)
```

Here the `append()` method adds `'ducati'` to the end of the list, without affecting any of the other elements in the list:

```
['honda', 'yamaha', 'suzuki']
['honda', 'yamaha', 'suzuki', 'ducati']
```

The `append()` method makes it easy to build lists dynamically. For example, you can start with an empty list and then add items to the list using a series of `append()` calls. Using an empty list, let's add the elements `'honda'`, `'yamaha'`, and `'suzuki'` to the list:

```
motorcycles = []

motorcycles.append('honda')
motorcycles.append('yamaha')
motorcycles.append('suzuki')

print(motorcycles)
```

The resulting list looks exactly the same as the lists in the previous examples:

```
['honda', 'yamaha', 'suzuki']
```

Building lists this way is very common, because you often won't know the data your users want to store in a program until after the program is running. To put your users in control, start by defining an empty list that will hold the users' values. Then append each new value provided to the list you just created.

Inserting Elements into a List

You can add a new element at any position in your list by using the `insert()` method. You do this by specifying the index of the new element and the value of the new item:

```
motorcycles = ['honda', 'yamaha', 'suzuki']

motorcycles.insert(0, 'ducati')
print(motorcycles)
```

In this example, we insert the value `'ducati'` at the beginning of the list. The `insert()` method opens a space at position `0` and stores the value `'ducati'` at that location:

```
['ducati', 'honda', 'yamaha', 'suzuki']
```

This operation shifts every other value in the list one position to the right.

Removing Elements from a List

Often, you'll want to remove an item or a set of items from a list. For example, when a player shoots down an alien from the sky, you'll most likely want to remove it from the list of active aliens. Or when a user decides to cancel their account on a web application you created, you'll want to remove that user from the list of active users. You can remove an item according to its position in the list or according to its value.

Removing an Item Using the del Statement

If you know the position of the item you want to remove from a list, you can use the `del` statement:

```
motorcycles = ['honda', 'yamaha', 'suzuki']
print(motorcycles)

del motorcycles[0]
print(motorcycles)
```

Here we use the `del` statement to remove the first item, `'honda'`, from the list of motorcycles:

```
['honda', 'yamaha', 'suzuki']
['yamaha', 'suzuki']
```

You can remove an item from any position in a list using the `del` statement if you know its index. For example, here's how to remove the second item, `'yamaha'`, from the list:

```
motorcycles = ['honda', 'yamaha', 'suzuki']
print(motorcycles)

del motorcycles[1]
print(motorcycles)
```

The second motorcycle is deleted from the list:

```
['honda', 'yamaha', 'suzuki']
['honda', 'suzuki']
```

In both examples, you can no longer access the value that was removed from the list after the `del` statement is used.

Removing an Item Using the pop() Method

Sometimes you'll want to use the value of an item after you remove it from a list. For example, you might want to get the *x* and *y* position of an alien that was just shot down, so you can draw an explosion at that position. In a web application, you might want to remove a user from a list of active members and then add that user to a list of inactive members.

The `pop()` method removes the last item in a list, but it lets you work with that item after removing it. The term *pop* comes from thinking of a list as a stack of items and popping one item off the top of the stack. In this analogy, the top of a stack corresponds to the end of a list.

Let's pop a motorcycle from the list of motorcycles:

```
❶ motorcycles = ['honda', 'yamaha', 'suzuki']
  print(motorcycles)

❷ popped_motorcycle = motorcycles.pop()
❸ print(motorcycles)
❹ print(popped_motorcycle)
```

We start by defining and printing the list `motorcycles` ❶. Then we pop a value from the list, and assign that value to the variable `popped_motorcycle` ❷. We print the list ❸ to show that a value has been removed from the list. Then we print the popped value ❹ to prove that we still have access to the value that was removed.

The output shows that the value `'suzuki'` was removed from the end of the list and is now assigned to the variable `popped_motorcycle`:

```
['honda', 'yamaha', 'suzuki']
['honda', 'yamaha']
suzuki
```

How might this `pop()` method be useful? Imagine that the motorcycles in the list are stored in chronological order, according to when we owned them. If this is the case, we can use the `pop()` method to print a statement about the last motorcycle we bought:

```
motorcycles = ['honda', 'yamaha', 'suzuki']

last_owned = motorcycles.pop()
print(f"The last motorcycle I owned was a {last_owned.title()}.")
```

The output is a simple sentence about the most recent motorcycle we owned:

```
The last motorcycle I owned was a Suzuki.
```

Popping Items from Any Position in a List

You can use `pop()` to remove an item from any position in a list by including the index of the item you want to remove in parentheses:

```
motorcycles = ['honda', 'yamaha', 'suzuki']

first_owned = motorcycles.pop(0)
print(f"The first motorcycle I owned was a {first_owned.title()}.")
```

We start by popping the first motorcycle in the list, and then we print a message about that motorcycle. The output is a simple sentence describing the first motorcycle I ever owned:

```
The first motorcycle I owned was a Honda.
```

Remember that each time you use `pop()`, the item you work with is no longer stored in the list.

If you're unsure whether to use the `del` statement or the `pop()` method, here's a simple way to decide: when you want to delete an item from a list and not use that item in any way, use the `del` statement; if you want to use an item as you remove it, use the `pop()` method.

Removing an Item by Value

Sometimes you won't know the position of the value you want to remove from a list. If you only know the value of the item you want to remove, you can use the `remove()` method.

For example, say we want to remove the value `'ducati'` from the list of motorcycles:

```
motorcycles = ['honda', 'yamaha', 'suzuki', 'ducati']
print(motorcycles)

motorcycles.remove('ducati')
print(motorcycles)
```

Here the `remove()` method tells Python to figure out where `'ducati'` appears in the list and remove that element:

```
['honda', 'yamaha', 'suzuki', 'ducati']
['honda', 'yamaha', 'suzuki']
```

You can also use the `remove()` method to work with a value that's being removed from a list. Let's remove the value `'ducati'` and print a reason for removing it from the list:

```
❶ motorcycles = ['honda', 'yamaha', 'suzuki', 'ducati']
  print(motorcycles)

❷ too_expensive = 'ducati'
❸ motorcycles.remove(too_expensive)
  print(motorcycles)
❹ print(f"\nA {too_expensive.title()} is too expensive for me.")
```

After defining the list ❶, we assign the value `'ducati'` to a variable called `too_expensive` ❷. We then use this variable to tell Python which value to remove from the list ❸. The value `'ducati'` has been removed from the list ❹ but is still accessible through the variable `too_expensive`, allowing us to print a statement about why we removed `'ducati'` from the list of motorcycles:

```
['honda', 'yamaha', 'suzuki', 'ducati']
['honda', 'yamaha', 'suzuki']

A Ducati is too expensive for me.
```

NOTE *The `remove()` method deletes only the first occurrence of the value you specify. If there's a possibility the value appears more than once in the list, you'll need to use a loop to make sure all occurrences of the value are removed. You'll learn how to do this in Chapter 7.*

TRY IT YOURSELF

The following exercises are a bit more complex than those in Chapter 2, but they give you an opportunity to use lists in all of the ways described.

3-4. Guest List: If you could invite anyone, living or deceased, to dinner, who would you invite? Make a list that includes at least three people you'd like to invite to dinner. Then use your list to print a message to each person, inviting them to dinner.

(continued)

3-5. Changing Guest List: You just heard that one of your guests can't make the dinner, so you need to send out a new set of invitations. You'll have to think of someone else to invite.

- Start with your program from Exercise 3-4. Add a `print()` call at the end of your program, stating the name of the guest who can't make it.
- Modify your list, replacing the name of the guest who can't make it with the name of the new person you are inviting.
- Print a second set of invitation messages, one for each person who is still in your list.

3-6. More Guests: You just found a bigger dinner table, so now more space is available. Think of three more guests to invite to dinner.

- Start with your program from Exercise 3-4 or 3-5. Add a `print()` call to the end of your program, informing people that you found a bigger table.
- Use `insert()` to add one new guest to the beginning of your list.
- Use `insert()` to add one new guest to the middle of your list.
- Use `append()` to add one new guest to the end of your list.
- Print a new set of invitation messages, one for each person in your list.

3-7. Shrinking Guest List: You just found out that your new dinner table won't arrive in time for the dinner, and now you have space for only two guests.

- Start with your program from Exercise 3-6. Add a new line that prints a message saying that you can invite only two people for dinner.
- Use `pop()` to remove guests from your list one at a time until only two names remain in your list. Each time you pop a name from your list, print a message to that person letting them know you're sorry you can't invite them to dinner.
- Print a message to each of the two people still on your list, letting them know they're still invited.
- Use `del` to remove the last two names from your list, so you have an empty list. Print your list to make sure you actually have an empty list at the end of your program.

Organizing a List

Often, your lists will be created in an unpredictable order, because you can't always control the order in which your users provide their data. Although this is unavoidable in most circumstances, you'll frequently want to present your information in a particular order. Sometimes you'll want

to preserve the original order of your list, and other times you'll want to change the original order. Python provides a number of different ways to organize your lists, depending on the situation.

Sorting a List Permanently with the sort() Method

Python's `sort()` method makes it relatively easy to sort a list. Imagine we have a list of cars and want to change the order of the list to store them alphabetically. To keep the task simple, let's assume that all the values in the list are lowercase:

cars.py

```
cars = ['bmw', 'audi', 'toyota', 'subaru']
cars.sort()
print(cars)
```

The `sort()` method changes the order of the list permanently. The cars are now in alphabetical order, and we can never revert to the original order:

```
['audi', 'bmw', 'subaru', 'toyota']
```

You can also sort this list in reverse-alphabetical order by passing the argument `reverse=True` to the `sort()` method. The following example sorts the list of cars in reverse-alphabetical order:

```
cars = ['bmw', 'audi', 'toyota', 'subaru']
cars.sort(reverse=True)
print(cars)
```

Again, the order of the list is permanently changed:

```
['toyota', 'subaru', 'bmw', 'audi']
```

Sorting a List Temporarily with the sorted() Function

To maintain the original order of a list but present it in a sorted order, you can use the `sorted()` function. The `sorted()` function lets you display your list in a particular order, but doesn't affect the actual order of the list.

Let's try this function on the list of cars.

```
cars = ['bmw', 'audi', 'toyota', 'subaru']

❶ print("Here is the original list:")
  print(cars)

❷ print("\nHere is the sorted list:")
  print(sorted(cars))

❸ print("\nHere is the original list again:")
  print(cars)
```

We first print the list in its original order ❶ and then in alphabetical order ❷. After the list is displayed in the new order, we show that the list is still stored in its original order ❸:

```
Here is the original list:
['bmw', 'audi', 'toyota', 'subaru']

Here is the sorted list:
['audi', 'bmw', 'subaru', 'toyota']

❶ Here is the original list again:
['bmw', 'audi', 'toyota', 'subaru']
```

Notice that the list still exists in its original order ❶ after the `sorted()` function has been used. The `sorted()` function can also accept a `reverse=True` argument if you want to display a list in reverse-alphabetical order.

NOTE *Sorting a list alphabetically is a bit more complicated when all the values are not in lowercase. There are several ways to interpret capital letters when determining a sort order, and specifying the exact order can be more complex than we want to deal with at this time. However, most approaches to sorting will build directly on what you learned in this section.*

Printing a List in Reverse Order

To reverse the original order of a list, you can use the `reverse()` method. If we originally stored the list of cars in chronological order according to when we owned them, we could easily rearrange the list into reverse-chronological order:

```
cars = ['bmw', 'audi', 'toyota', 'subaru']
print(cars)

cars.reverse()
print(cars)
```

Notice that `reverse()` doesn't sort backward alphabetically; it simply reverses the order of the list:

```
['bmw', 'audi', 'toyota', 'subaru']
['subaru', 'toyota', 'audi', 'bmw']
```

The `reverse()` method changes the order of a list permanently, but you can revert to the original order anytime by applying `reverse()` to the same list a second time.

Finding the Length of a List

You can quickly find the length of a list by using the `len()` function. The list in this example has four items, so its length is `4`:

```
>>> cars = ['bmw', 'audi', 'toyota', 'subaru']
>>> len(cars)
4
```

You'll find `len()` useful when you need to identify the number of aliens that still need to be shot down in a game, determine the amount of data you have to manage in a visualization, or figure out the number of registered users on a website, among other tasks.

NOTE *Python counts the items in a list starting with one, so you shouldn't run into any off-by-one errors when determining the length of a list.*

TRY IT YOURSELF

3-8. Seeing the World: Think of at least five places in the world you'd like to visit.

- Store the locations in a list. Make sure the list is not in alphabetical order.
- Print your list in its original order. Don't worry about printing the list neatly; just print it as a raw Python list.
- Use `sorted()` to print your list in alphabetical order without modifying the actual list.
- Show that your list is still in its original order by printing it.
- Use `sorted()` to print your list in reverse-alphabetical order without changing the order of the original list.
- Show that your list is still in its original order by printing it again.
- Use `reverse()` to change the order of your list. Print the list to show that its order has changed.
- Use `reverse()` to change the order of your list again. Print the list to show it's back to its original order.
- Use `sort()` to change your list so it's stored in alphabetical order. Print the list to show that its order has been changed.
- Use `sort()` to change your list so it's stored in reverse-alphabetical order. Print the list to show that its order has changed.

3-9. Dinner Guests: Working with one of the programs from Exercises 3-4 through 3-7 (pages 41–42), use `len()` to print a message indicating the number of people you're inviting to dinner.

3-10. Every Function: Think of things you could store in a list. For example, you could make a list of mountains, rivers, countries, cities, languages, or anything else you'd like. Write a program that creates a list containing these items and then uses each function introduced in this chapter at least once.

Avoiding Index Errors When Working with Lists

There's one type of error that's common to see when you're working with lists for the first time. Let's say you have a list with three items, and you ask for the fourth item:

motorcycles.py

```
motorcycles = ['honda', 'yamaha', 'suzuki']
print(motorcycles[3])
```

This example results in an *index error*:

```
Traceback (most recent call last):
  File "motorcycles.py", line 2, in <module>
    print(motorcycles[3])
          ~~~~~~~~~~~^^^
IndexError: list index out of range
```

Python attempts to give you the item at index 3. But when it searches the list, no item in `motorcycles` has an index of 3. Because of the off-by-one nature of indexing in lists, this error is typical. People think the third item is item number 3, because they start counting at 1. But in Python the third item is number 2, because it starts indexing at 0.

An index error means Python can't find an item at the index you requested. If an index error occurs in your program, try adjusting the index you're asking for by one. Then run the program again to see if the results are correct.

Keep in mind that whenever you want to access the last item in a list, you should use the index `-1`. This will always work, even if your list has changed size since the last time you accessed it:

```
motorcycles = ['honda', 'yamaha', 'suzuki']
print(motorcycles[-1])
```

The index `-1` always returns the last item in a list, in this case the value `'suzuki'`:

```
suzuki
```

The only time this approach will cause an error is when you request the last item from an empty list:

```
motorcycles = []
print(motorcycles[-1])
```

No items are in `motorcycles`, so Python returns another index error:

```
Traceback (most recent call last):
  File "motorcyles.py", line 3, in <module>
    print(motorcycles[-1])
          ~~~~~~~~~~~^^^^
IndexError: list index out of range
```

If an index error occurs and you can't figure out how to resolve it, try printing your list or just printing the length of your list. Your list might look much different than you thought it did, especially if it has been managed dynamically by your program. Seeing the actual list, or the exact number of items in your list, can help you sort out such logical errors.

TRY IT YOURSELF

3-11. Intentional Error: If you haven't received an index error in one of your programs yet, try to make one happen. Change an index in one of your programs to produce an index error. Make sure you correct the error before closing the program.

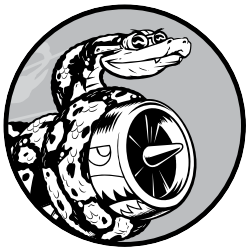
Summary

In this chapter, you learned what lists are and how to work with the individual items in a list. You learned how to define a list and how to add and remove elements. You learned how to sort lists permanently and temporarily for display purposes. You also learned how to find the length of a list and how to avoid index errors when you're working with lists.

In Chapter 4 you'll learn how to work with items in a list more efficiently. By looping through each item in a list using just a few lines of code you'll be able to work efficiently, even when your list contains thousands or millions of items.

4

WORKING WITH LISTS



In Chapter 3 you learned how to make a simple list, and you learned to work with the individual elements in a list. In this chapter you'll learn how to loop through an entire list using just a few lines of code, regardless of how long the list is. *Looping* allows you to take the same action, or set of actions, with every item in a list. As a result, you'll be able to work efficiently with lists of any length, including those with thousands or even millions of items.

Looping Through an Entire List

You'll often want to run through all entries in a list, performing the same task with each item. For example, in a game you might want to move every element on the screen by the same amount. In a list of numbers, you might want to perform the same statistical operation on every element.

Or perhaps you'll want to display each headline from a list of articles on a website. When you want to do the same action with every item in a list, you can use Python's `for` loop.

Say we have a list of magicians' names, and we want to print out each name in the list. We could do this by retrieving each name from the list individually, but this approach could cause several problems. For one, it would be repetitive to do this with a long list of names. Also, we'd have to change our code each time the list's length changed. Using a `for` loop avoids both of these issues by letting Python manage these issues internally.

Let's use a `for` loop to print out each name in a list of magicians:

magicians.py

```
magicians = ['alice', 'david', 'carolina']
for magician in magicians:
    print(magician)
```

We begin by defining a list, just as we did in Chapter 3. Then we define a `for` loop. This line tells Python to pull a name from the list `magicians`, and associate it with the variable `magician`. Next, we tell Python to print the name that's just been assigned to `magician`. Python then repeats these last two lines, once for each name in the list. It might help to read this code as "For every magician in the list of magicians, print the magician's name." The output is a simple printout of each name in the list:

```
alice
david
carolina
```

A Closer Look at Looping

Looping is important because it's one of the most common ways a computer automates repetitive tasks. For example, in a simple loop like we used in *magicians.py*, Python initially reads the first line of the loop:

```
for magician in magicians:
```

This line tells Python to retrieve the first value from the list `magicians` and associate it with the variable `magician`. This first value is `'alice'`. Python then reads the next line:

```
    print(magician)
```

Python prints the current value of `magician`, which is still `'alice'`. Because the list contains more values, Python returns to the first line of the loop:

```
for magician in magicians:
```

Python retrieves the next name in the list, `'david'`, and associates that value with the variable `magician`. Python then executes the line:

```
    print(magician)
```

Python prints the current value of `magician` again, which is now `'david'`. Python repeats the entire loop once more with the last value in the list, `'carolina'`. Because no more values are in the list, Python moves on to the next line in the program. In this case nothing comes after the `for` loop, so the program ends.

When you're using loops for the first time, keep in mind that the set of steps is repeated once for each item in the list, no matter how many items are in the list. If you have a million items in your list, Python repeats these steps a million times—and usually very quickly.

Also keep in mind when writing your own `for` loops that you can choose any name you want for the temporary variable that will be associated with each value in the list. However, it's helpful to choose a meaningful name that represents a single item from the list. For example, here's a good way to start a `for` loop for a list of cats, a list of dogs, and a general list of items:

```
for cat in cats:
for dog in dogs:
for item in list_of_items:
```

These naming conventions can help you follow the action being done on each item within a `for` loop. Using singular and plural names can help you identify whether a section of code is working with a single element from the list or the entire list.

Doing More Work Within a for Loop

You can do just about anything with each item in a `for` loop. Let's build on the previous example by printing a message to each magician, telling them that they performed a great trick:

magicians.py

```
magicians = ['alice', 'david', 'carolina']
for magician in magicians:
    print(f"{magician.title()}, that was a great trick!")
```

The only difference in this code is where we compose a message to each magician, starting with that magician's name. The first time through the loop the value of `magician` is `'alice'`, so Python starts the first message with the name `'Alice'`. The second time through, the message will begin with `'David'`, and the third time through, the message will begin with `'Carolina'`.

The output shows a personalized message for each magician in the list:

```
Alice, that was a great trick!
David, that was a great trick!
Carolina, that was a great trick!
```

You can also write as many lines of code as you like in the `for` loop. Every indented line following the line `for magician in magicians` is considered *inside the loop*, and each indented line is executed once for each value in the list. Therefore, you can do as much work as you like with each value in the list.

Let's add a second line to our message, telling each magician that we're looking forward to their next trick:

```
magicians = ['alice', 'david', 'carolina']
for magician in magicians:
    print(f"{magician.title()}, that was a great trick!")
    print(f"I can't wait to see your next trick, {magician.title()}.\n")
```

Because we have indented both calls to `print()`, each line will be executed once for every magician in the list. The newline (`"\n"`) in the second `print()` call inserts a blank line after each pass through the loop. This creates a set of messages that are neatly grouped for each person in the list:

```
Alice, that was a great trick!
I can't wait to see your next trick, Alice.

David, that was a great trick!
I can't wait to see your next trick, David.

Carolina, that was a great trick!
I can't wait to see your next trick, Carolina.
```

You can use as many lines as you like in your `for` loops. In practice, you'll often find it useful to do a number of different operations with each item in a list when you use a `for` loop.

Doing Something After a for Loop

What happens once a `for` loop has finished executing? Usually, you'll want to summarize a block of output or move on to other work that your program must accomplish.

Any lines of code after the `for` loop that are not indented are executed once without repetition. Let's write a thank you to the group of magicians as a whole, thanking them for putting on an excellent show. To display this group message after all of the individual messages have been printed, we place the thank you message after the `for` loop, without indentation:

```
magicians = ['alice', 'david', 'carolina']
for magician in magicians:
    print(f"{magician.title()}, that was a great trick!")
    print(f"I can't wait to see your next trick, {magician.title()}.\n")

print("Thank you, everyone. That was a great magic show!")
```

The first two calls to `print()` are repeated once for each magician in the list, as you saw earlier. However, because the last line is not indented, it's printed only once:

```
Alice, that was a great trick!
I can't wait to see your next trick, Alice.

David, that was a great trick!
```

```
I can't wait to see your next trick, David.

Carolina, that was a great trick!
I can't wait to see your next trick, Carolina.

Thank you, everyone. That was a great magic show!
```

When you're processing data using a `for` loop, you'll find that this is a good way to summarize an operation that was performed on an entire dataset. For example, you might use a `for` loop to initialize a game by running through a list of characters and displaying each character on the screen. You might then write some additional code after this loop that displays a *Play Now* button after all the characters have been drawn to the screen.

Avoiding Indentation Errors

Python uses indentation to determine how a line, or group of lines, is related to the rest of the program. In the previous examples, the lines that printed messages to individual magicians were part of the `for` loop because they were indented. Python's use of indentation makes code very easy to read. Basically, it uses whitespace to force you to write neatly formatted code with a clear visual structure. In longer Python programs, you'll notice blocks of code indented at a few different levels. These indentation levels help you gain a general sense of the overall program's organization.

As you begin to write code that relies on proper indentation, you'll need to watch for a few common *indentation errors*. For example, people sometimes indent lines of code that don't need to be indented or forget to indent lines that need to be indented. Seeing examples of these errors now will help you avoid them in the future and correct them when they do appear in your own programs.

Let's examine some of the more common indentation errors.

Forgetting to Indent

Always indent the line after the `for` statement in a loop. If you forget, Python will remind you:

magicians.py

```
magicians = ['alice', 'david', 'carolina']
for magician in magicians:
❶ print(magician)
```

The call to `print()` ❶ should be indented, but it's not. When Python expects an indented block and doesn't find one, it lets you know which line it had a problem with:

```
  File "magicians.py", line 3
    print(magician)
    ^
IndentationError: expected an indented block after 'for' statement on line 2
```

You can usually resolve this kind of indentation error by indenting the line or lines immediately after the `for` statement.

Forgetting to Indent Additional Lines

Sometimes your loop will run without any errors but won't produce the expected result. This can happen when you're trying to do several tasks in a loop and you forget to indent some of its lines.

For example, this is what happens when we forget to indent the second line in the loop that tells each magician we're looking forward to their next trick:

```
magicians = ['alice', 'david', 'carolina']
for magician in magicians:
    print(f"{magician.title()}, that was a great trick!")
❶ print(f"I can't wait to see your next trick, {magician.title()}.\n")
```

The second call to `print()` ❶ is supposed to be indented, but because Python finds at least one indented line after the `for` statement, it doesn't report an error. As a result, the first `print()` call is executed once for each name in the list because it is indented. The second `print()` call is not indented, so it is executed only once after the loop has finished running. Because the final value associated with `magician` is `'carolina'`, she is the only one who receives the "looking forward to the next trick" message:

```
Alice, that was a great trick!
David, that was a great trick!
Carolina, that was a great trick!
I can't wait to see your next trick, Carolina.
```

This is a *logical error*. The syntax is valid Python code, but the code does not produce the desired result because a problem occurs in its logic. If you expect to see a certain action repeated once for each item in a list and it's executed only once, determine whether you need to simply indent a line or a group of lines.

Indenting Unnecessarily

If you accidentally indent a line that doesn't need to be indented, Python informs you about the unexpected indent:

hello_world.py

```
message = "Hello Python world!"
    print(message)
```

We don't need to indent the `print()` call, because it isn't part of a loop; hence, Python reports that error:

```
  File "hello_world.py", line 2
    print(message)
    ^
IndentationError: unexpected indent
```

You can avoid unexpected indentation errors by indenting only when you have a specific reason to do so. In the programs you're writing at this point, the only lines you should indent are the actions you want to repeat for each item in a `for` loop.

Indenting Unnecessarily After the Loop

If you accidentally indent code that should run after a loop has finished, that code will be repeated once for each item in the list. Sometimes this prompts Python to report an error, but often this will result in a logical error.

For example, let's see what happens when we accidentally indent the line that thanked the magicians as a group for putting on a good show:

magicians.py

```
magicians = ['alice', 'david', 'carolina']
for magician in magicians:
    print(f"{magician.title()}, that was a great trick!")
    print(f"I can't wait to see your next trick, {magician.title()}.\n")

❶   print("Thank you everyone, that was a great magic show!")
```

Because the last line ❶ is indented, it's printed once for each person in the list:

```
Alice, that was a great trick!
I can't wait to see your next trick, Alice.

Thank you everyone, that was a great magic show!
David, that was a great trick!
I can't wait to see your next trick, David.

Thank you everyone, that was a great magic show!
Carolina, that was a great trick!
I can't wait to see your next trick, Carolina.

Thank you everyone, that was a great magic show!
```

This is another logical error, similar to the one in "Forgetting to Indent Additional Lines" on page 54. Because Python doesn't know what you're trying to accomplish with your code, it will run all code that is written in valid syntax. If an action is repeated many times when it should be executed only once, you probably need to unindent the code for that action.

Forgetting the Colon

The colon at the end of a `for` statement tells Python to interpret the next line as the start of a loop.

```
magicians = ['alice', 'david', 'carolina']
❶ for magician in magicians
    print(magician)
```

If you accidentally forget the colon ❶, you'll get a syntax error because Python doesn't know exactly what you're trying to do:

```
  File "magicians.py", line 2
    for magician in magicians
                             ^
SyntaxError: expected ':'
```

Python doesn't know if you simply forgot the colon, or if you meant to write additional code to set up a more complex loop. If the interpreter can identify a possible fix it will suggest one, like adding a colon at the end of a line, as it does here with the response `expected ':'`. Some errors have easy, obvious fixes, thanks to the suggestions in Python's tracebacks. Some errors are much harder to resolve, even when the eventual fix only involves a single character. Don't feel bad when a small fix takes a long time to find; you are absolutely not alone in this experience.

TRY IT YOURSELF

4-1. Pizzas: Think of at least three kinds of your favorite pizza. Store these pizza names in a list, and then use a `for` loop to print the name of each pizza.

- Modify your `for` loop to print a sentence using the name of the pizza, instead of printing just the name of the pizza. For each pizza, you should have one line of output containing a simple statement like *I like pepperoni pizza*.
- Add a line at the end of your program, outside the `for` loop, that states how much you like pizza. The output should consist of three or more lines about the kinds of pizza you like and then an additional sentence, such as *I really love pizza!*

4-2. Animals: Think of at least three different animals that have a common characteristic. Store the names of these animals in a list, and then use a `for` loop to print out the name of each animal.

- Modify your program to print a statement about each animal, such as *A dog would make a great pet.*
- Add a line at the end of your program, stating what these animals have in common. You could print a sentence, such as *Any of these animals would make a great pet!*

Making Numerical Lists

Many reasons exist to store a set of numbers. For example, you'll need to keep track of the positions of each character in a game, and you might want

to keep track of a player's high scores as well. In data visualizations, you'll almost always work with sets of numbers, such as temperatures, distances, population sizes, or latitude and longitude values, among other types of numerical sets.

Lists are ideal for storing sets of numbers, and Python provides a variety of tools to help you work efficiently with lists of numbers. Once you understand how to use these tools effectively, your code will work well even when your lists contain millions of items.

Using the range() Function

Python's `range()` function makes it easy to generate a series of numbers. For example, you can use the `range()` function to print a series of numbers like this:

first_numbers.py

```
for value in range(1, 5):
    print(value)
```

Although this code looks like it should print the numbers from 1 to 5, it doesn't print the number 5:

```
1
2
3
4
```

In this example, `range()` prints only the numbers 1 through 4. This is another result of the off-by-one behavior you'll see often in programming languages. The `range()` function causes Python to start counting at the first value you give it, and it stops when it reaches the second value you provide. Because it stops at that second value, the output never contains the end value, which would have been 5 in this case.

To print the numbers from 1 to 5, you would use `range(1, 6)`:

```
for value in range(1, 6):
    print(value)
```

This time the output starts at 1 and ends at 5:

```
1
2
3
4
5
```

If your output is different from what you expect when you're using `range()`, try adjusting your end value by 1.

You can also pass `range()` only one argument, and it will start the sequence of numbers at 0. For example, `range(6)` would return the numbers from 0 through 5.

Using range() to Make a List of Numbers

If you want to make a list of numbers, you can convert the results of `range()` directly into a list using the `list()` function. When you wrap `list()` around a call to the `range()` function, the output will be a list of numbers.

In the example in the previous section, we simply printed out a series of numbers. We can use `list()` to convert that same set of numbers into a list:

```
numbers = list(range(1, 6))
print(numbers)
```

This is the result:

```
[1, 2, 3, 4, 5]
```

We can also use the `range()` function to tell Python to skip numbers in a given range. If you pass a third argument to `range()`, Python uses that value as a step size when generating numbers.

For example, here's how to list the even numbers between 1 and 10:

even_numbers.py

```
even_numbers = list(range(2, 11, 2))
print(even_numbers)
```

In this example, the `range()` function starts with the value 2 and then adds 2 to that value. It adds 2 repeatedly until it reaches or passes the end value, 11, and produces this result:

```
[2, 4, 6, 8, 10]
```

You can create almost any set of numbers you want to using the `range()` function. For example, consider how you might make a list of the first 10 square numbers (that is, the square of each integer from 1 through 10). In Python, two asterisks (**) represent exponents. Here's how you might put the first 10 square numbers into a list:

square_numbers.py

```
squares = []
for value in range(1, 11):
❶    square = value ** 2
❷    squares.append(square)

print(squares)
```

We start with an empty list called `squares`. Then, we tell Python to loop through each value from 1 to 10 using the `range()` function. Inside the loop, the current value is raised to the second power and assigned to the variable `square` ❶. Each new value of `square` is then appended to the list `squares` ❷. Finally, when the loop has finished running, the list of squares is printed:

```
[1, 4, 9, 16, 25, 36, 49, 64, 81, 100]
```

To write this code more concisely, omit the temporary variable `square` and append each new value directly to the list:

```
squares = []
for value in range(1,11):
    squares.append(value**2)

print(squares)
```

This line does the same work as the lines inside the `for` loop in the previous listing. Each value in the loop is raised to the second power and then immediately appended to the list of squares.

You can use either of these approaches when you're making more complex lists. Sometimes using a temporary variable makes your code easier to read; other times it makes the code unnecessarily long. Focus first on writing code that you understand clearly, and does what you want it to do. Then look for more efficient approaches as you review your code.

Simple Statistics with a List of Numbers

A few Python functions are helpful when working with lists of numbers. For example, you can easily find the minimum, maximum, and sum of a list of numbers:

```
>>> digits = [1, 2, 3, 4, 5, 6, 7, 8, 9, 0]
>>> min(digits)
0
>>> max(digits)
9
>>> sum(digits)
45
```

NOTE *The examples in this section use short lists of numbers that fit easily on the page. They would work just as well if your list contained a million or more numbers.*

List Comprehensions

The approach described earlier for generating the list `squares` consisted of using three or four lines of code. A *list comprehension* allows you to generate this same list in just one line of code. A list comprehension combines the `for` loop and the creation of new elements into one line, and automatically appends each new element. List comprehensions are not always presented to beginners, but I've included them here because you'll most likely see them as soon as you start looking at other people's code.

The following example builds the same list of square numbers you saw earlier but uses a list comprehension:

squares.py

```
squares = [value**2 for value in range(1, 11)]
print(squares)
```

To use this syntax, begin with a descriptive name for the list, such as `squares`. Next, open a set of square brackets and define the expression for the values you want to store in the new list. In this example the expression is `value**2`, which raises the value to the second power. Then, write a `for` loop to generate the numbers you want to feed into the expression, and close the square brackets. The `for` loop in this example is `for value in range(1, 11)`, which feeds the values 1 through 10 into the expression `value**2`. Note that no colon is used at the end of the `for` statement.

The result is the same list of square numbers you saw earlier:

```
[1, 4, 9, 16, 25, 36, 49, 64, 81, 100]
```

It takes practice to write your own list comprehensions, but you'll find them worthwhile once you become comfortable creating ordinary lists. When you're writing three or four lines of code to generate lists and it begins to feel repetitive, consider writing your own list comprehensions.

TRY IT YOURSELF

4-3. Counting to Twenty: Use a `for` loop to print the numbers from 1 to 20, inclusive.

4-4. One Million: Make a list of the numbers from one to one million, and then use a `for` loop to print the numbers. (If the output is taking too long, stop it by pressing CTRL-C or by closing the output window.)

4-5. Summing a Million: Make a list of the numbers from one to one million, and then use `min()` and `max()` to make sure your list actually starts at one and ends at one million. Also, use the `sum()` function to see how quickly Python can add a million numbers.

4-6. Odd Numbers: Use the third argument of the `range()` function to make a list of the odd numbers from 1 to 20. Use a `for` loop to print each number.

4-7. Threes: Make a list of the multiples of 3, from 3 to 30. Use a `for` loop to print the numbers in your list.

4-8. Cubes: A number raised to the third power is called a *cube*. For example, the cube of 2 is written as `2**3` in Python. Make a list of the first 10 cubes (that is, the cube of each integer from 1 through 10), and use a `for` loop to print out the value of each cube.

4-9. Cube Comprehension: Use a list comprehension to generate a list of the first 10 cubes.

Working with Part of a List

In Chapter 3 you learned how to access single elements in a list, and in this chapter you've been learning how to work through all the elements in a list. You can also work with a specific group of items in a list, called a *slice* in Python.

Slicing a List

To make a slice, you specify the index of the first and last elements you want to work with. As with the `range()` function, Python stops one item before the second index you specify. To output the first three elements in a list, you would request indices `0` through `3`, which would return elements `0`, `1`, and `2`.

The following example involves a list of players on a team:

players.py

```
players = ['charles', 'martina', 'michael', 'florence', 'eli']
print(players[0:3])
```

This code prints a slice of the list. The output retains the structure of the list, and includes the first three players in the list:

```
['charles', 'martina', 'michael']
```

You can generate any subset of a list. For example, if you want the second, third, and fourth items in a list, you would start the slice at index `1` and end it at index `4`:

```
players = ['charles', 'martina', 'michael', 'florence', 'eli']
print(players[1:4])
```

This time the slice starts with `'martina'` and ends with `'florence'`:

```
['martina', 'michael', 'florence']
```

If you omit the first index in a slice, Python automatically starts your slice at the beginning of the list:

```
players = ['charles', 'martina', 'michael', 'florence', 'eli']
print(players[:4])
```

Without a starting index, Python starts at the beginning of the list:

```
['charles', 'martina', 'michael', 'florence']
```

A similar syntax works if you want a slice that includes the end of a list. For example, if you want all items from the third item through the last item, you can start with index `2` and omit the second index:

```
players = ['charles', 'martina', 'michael', 'florence', 'eli']
print(players[2:])
```

Python returns all items from the third item through the end of the list:

```
['michael', 'florence', 'eli']
```

This syntax allows you to output all of the elements from any point in your list to the end, regardless of the length of the list. Recall that a negative index returns an element a certain distance from the end of a list; therefore, you can output any slice from the end of a list. For example, if we want to output the last three players on the roster, we can use the slice `players[-3:]`:

```
players = ['charles', 'martina', 'michael', 'florence', 'eli']
print(players[-3:])
```

This prints the names of the last three players and will continue to work as the list of players changes in size.

NOTE *You can include a third value in the brackets indicating a slice. If a third value is included, this tells Python how many items to skip between items in the specified range.*

Looping Through a Slice

You can use a slice in a `for` loop if you want to loop through a subset of the elements in a list. In the next example, we loop through the first three players and print their names as part of a simple roster:

```
players = ['charles', 'martina', 'michael', 'florence', 'eli']

print("Here are the first three players on my team:")
❶ for player in players[:3]:
    print(player.title())
```

Instead of looping through the entire list of players, Python loops through only the first three names ❶:

```
Here are the first three players on my team:
Charles
Martina
Michael
```

Slices are very useful in a number of situations. For instance, when you're creating a game, you could add a player's final score to a list every time that player finishes playing. You could then get a player's top three scores by sorting the list in decreasing order and taking a slice that includes just the first three scores. When you're working with data, you can use slices to process your data in chunks of a specific size. Or, when you're building a web application, you could use slices to display information in a series of pages with an appropriate amount of information on each page.

Copying a List

Often, you'll want to start with an existing list and make an entirely new list based on the first one. Let's explore how copying a list works and examine one situation in which copying a list is useful.

To copy a list, you can make a slice that includes the entire original list by omitting the first index and the second index ([:]). This tells Python to make a slice that starts at the first item and ends with the last item, producing a copy of the entire list.

For example, imagine we have a list of our favorite foods and want to make a separate list of foods that a friend likes. This friend likes everything in our list so far, so we can create their list by copying ours:

foods.py

```
my_foods = ['pizza', 'falafel', 'carrot cake']
❶ friend_foods = my_foods[:]

print("My favorite foods are:")
print(my_foods)

print("\nMy friend's favorite foods are:")
print(friend_foods)
```

First, we make a list of the foods we like called `my_foods`. Then we make a new list called `friend_foods`. We make a copy of `my_foods` by asking for a slice of `my_foods` without specifying any indices ❶, and assign the copy to `friend_foods`. When we print each list, we see that they both contain the same foods:

```
My favorite foods are:
['pizza', 'falafel', 'carrot cake']

My friend's favorite foods are:
['pizza', 'falafel', 'carrot cake']
```

To prove that we actually have two separate lists, we'll add a new food to each list and show that each list keeps track of the appropriate person's favorite foods:

```
my_foods = ['pizza', 'falafel', 'carrot cake']
❶ friend_foods = my_foods[:]

❷ my_foods.append('cannoli')
❸ friend_foods.append('ice cream')

print("My favorite foods are:")
print(my_foods)

print("\nMy friend's favorite foods are:")
print(friend_foods)
```

We copy the original items in `my_foods` to the new list `friend_foods`, as we did in the previous example ❶. Next, we add a new food to each list: we add `'cannoli'` to `my_foods` ❷, and we add `'ice cream'` to `friend_foods` ❸. We then print the two lists to see whether each of these foods is in the appropriate list:

```
My favorite foods are:
['pizza', 'falafel', 'carrot cake', 'cannoli']

My friend's favorite foods are:
['pizza', 'falafel', 'carrot cake', 'ice cream']
```

The output shows that `'cannoli'` now appears in our list of favorite foods but `'ice cream'` does not. We can see that `'ice cream'` now appears in our friend's list but `'cannoli'` does not. If we had simply set `friend_foods` equal to `my_foods`, we would not produce two separate lists. For example, here's what happens when you try to copy a list without using a slice:

```
my_foods = ['pizza', 'falafel', 'carrot cake']

# This doesn't work:
friend_foods = my_foods

my_foods.append('cannoli')
friend_foods.append('ice cream')

print("My favorite foods are:")
print(my_foods)

print("\nMy friend's favorite foods are:")
print(friend_foods)
```

Instead of assigning a copy of `my_foods` to `friend_foods`, we set `friend_foods` equal to `my_foods`. This syntax actually tells Python to associate the new variable `friend_foods` with the list that is already associated with `my_foods`, so now both variables point to the same list. As a result, when we add `'cannoli'` to `my_foods`, it will also appear in `friend_foods`. Likewise `'ice cream'` will appear in both lists, even though it appears to be added only to `friend_foods`.

The output shows that both lists are the same now, which is not what we wanted:

```
My favorite foods are:
['pizza', 'falafel', 'carrot cake', 'cannoli', 'ice cream']

My friend's favorite foods are:
['pizza', 'falafel', 'carrot cake', 'cannoli', 'ice cream']
```

NOTE *Don't worry about the details in this example for now. If you're trying to work with a copy of a list and you see unexpected behavior, make sure you are copying the list using a slice, as we did in the first example.*

TRY IT YOURSELF

4-10. Slices: Using one of the programs you wrote in this chapter, add several lines to the end of the program that do the following:

- Print the message *The first three items in the list are:*. Then use a slice to print the first three items from that program's list.
- Print the message *Three items from the middle of the list are:*. Then use a slice to print three items from the middle of the list.
- Print the message *The last three items in the list are:*. Then use a slice to print the last three items in the list.

4-11. My Pizzas, Your Pizzas: Start with your program from Exercise 4-1 (page 56). Make a copy of the list of pizzas, and call it `friend_pizzas`. Then, do the following:

- Add a new pizza to the original list.
- Add a different pizza to the list `friend_pizzas`.
- Prove that you have two separate lists. Print the message *My favorite pizzas are:*, and then use a `for` loop to print the first list. Print the message *My friend's favorite pizzas are:*, and then use a `for` loop to print the second list. Make sure each new pizza is stored in the appropriate list.

4-12. More Loops: All versions of *foods.py* in this section have avoided using `for` loops when printing, to save space. Choose a version of *foods.py*, and write two `for` loops to print each list of foods.

Tuples

Lists work well for storing collections of items that can change throughout the life of a program. The ability to modify lists is particularly important when you're working with a list of users on a website or a list of characters in a game. However, sometimes you'll want to create a list of items that cannot change. Tuples allow you to do just that. Python refers to values that cannot change as *immutable*, and an immutable list is called a *tuple*.

Defining a Tuple

A tuple looks just like a list, except you use parentheses instead of square brackets. Once you define a tuple, you can access individual elements by using each item's index, just as you would for a list.

For example, if we have a rectangle that should always be a certain size, we can ensure that its size doesn't change by putting the dimensions into a tuple:

dimensions.py

```
dimensions = (200, 50)
print(dimensions[0])
print(dimensions[1])
```

We define the tuple `dimensions`, using parentheses instead of square brackets. Then we print each element in the tuple individually, using the same syntax we've been using to access elements in a list:

```
200
50
```

Let's see what happens if we try to change one of the items in the tuple `dimensions`:

```
dimensions = (200, 50)
dimensions[0] = 250
```

This code tries to change the value of the first dimension, but Python returns a type error. Because we're trying to alter a tuple, which can't be done to that type of object, Python tells us we can't assign a new value to an item in a tuple:

```
Traceback (most recent call last):
  File "dimensions.py", line 2, in <module>
    dimensions[0] = 250
TypeError: 'tuple' object does not support item assignment
```

This is beneficial because we want Python to raise an error when a line of code tries to change the dimensions of the rectangle.

NOTE *Tuples are technically defined by the presence of a comma; the parentheses make them look neater and more readable. If you want to define a tuple with one element, you need to include a trailing comma:*

```
my_t = (3,)
```

It doesn't often make sense to build a tuple with one element, but this can happen when tuples are generated automatically.

Looping Through All Values in a Tuple

You can loop over all the values in a tuple using a `for` loop, just as you did with a list:

```
dimensions = (200, 50)
for dimension in dimensions:
    print(dimension)
```

Python returns all the elements in the tuple, just as it would for a list:

```
200
50
```

Writing Over a Tuple

Although you can't modify a tuple, you can assign a new value to a variable that represents a tuple. For example, if we wanted to change the dimensions of this rectangle, we could redefine the entire tuple:

```
dimensions = (200, 50)
print("Original dimensions:")
for dimension in dimensions:
    print(dimension)

dimensions = (400, 100)
print("\nModified dimensions:")
for dimension in dimensions:
    print(dimension)
```

The first four lines define the original tuple and print the initial dimensions. We then associate a new tuple with the variable `dimensions`, and print the new values. Python doesn't raise any errors this time, because reassigning a variable is valid:

```
Original dimensions:
200
50

Modified dimensions:
400
100
```

When compared with lists, tuples are simple data structures. Use them when you want to store a set of values that should not be changed throughout the life of a program.

TRY IT YOURSELF

4-13. Buffet: A buffet-style restaurant offers only five basic foods. Think of five simple foods, and store them in a tuple.

- Use a `for` loop to print each food the restaurant offers.
- Try to modify one of the items, and make sure that Python rejects the change.
- The restaurant changes its menu, replacing two of the items with different foods. Add a line that rewrites the tuple, and then use a `for` loop to print each of the items on the revised menu.

Styling Your Code

Now that you're writing longer programs, it's a good idea to learn how to style your code consistently. Take the time to make your code as easy as possible to read. Writing easy-to-read code helps you keep track of what your programs are doing and helps others understand your code as well.

Python programmers have agreed on a number of styling conventions to ensure that everyone's code is structured in roughly the same way. Once you've learned to write clean Python code, you should be able to understand the overall structure of anyone else's Python code, as long as they follow the same guidelines. If you're hoping to become a professional programmer at some point, you should begin following these guidelines as soon as possible to develop good habits.

The Style Guide

When someone wants to make a change to the Python language, they write a *Python Enhancement Proposal (PEP)*. One of the oldest PEPs is *PEP 8*, which instructs Python programmers on how to style their code. PEP 8 is fairly lengthy, but much of it relates to more complex coding structures than what you've seen so far.

The Python style guide was written with the understanding that code is read more often than it is written. You'll write your code once and then start reading it as you begin debugging. When you add features to a program, you'll spend more time reading your code. When you share your code with other programmers, they'll read your code as well.

Given the choice between writing code that's easier to write or code that's easier to read, Python programmers will almost always encourage you to write code that's easier to read. The following guidelines will help you write clear code from the start.

Indentation

PEP 8 recommends that you use four spaces per indentation level. Using four spaces improves readability while leaving room for multiple levels of indentation on each line.

In a word processing document, people often use tabs rather than spaces to indent. This works well for word processing documents, but the Python interpreter gets confused when tabs are mixed with spaces. Every text editor provides a setting that lets you use the TAB key but then converts each tab to a set number of spaces. You should definitely use your TAB key, but also make sure your editor is set to insert spaces rather than tabs into your document.

Mixing tabs and spaces in your file can cause problems that are very difficult to diagnose. If you think you have a mix of tabs and spaces, you can convert all tabs in a file to spaces in most editors.

Line Length

Many Python programmers recommend that each line should be less than 80 characters. Historically, this guideline developed because most computers could fit only 79 characters on a single line in a terminal window. Currently, people can fit much longer lines on their screens, but other reasons exist to adhere to the 79-character standard line length.

Professional programmers often have several files open on the same screen, and using the standard line length allows them to see entire lines in two or three files that are open side by side onscreen. PEP 8 also recommends that you limit all of your comments to 72 characters per line, because some of the tools that generate automatic documentation for larger projects add formatting characters at the beginning of each commented line.

The PEP 8 guidelines for line length are not set in stone, and some teams prefer a 99-character limit. Don't worry too much about line length in your code as you're learning, but be aware that people who are working collaboratively almost always follow the PEP 8 guidelines. Most editors allow you to set up a visual cue, usually a vertical line on your screen, that shows you where these limits are.

NOTE *Appendix B shows you how to configure your text editor so it always inserts four spaces each time you press the TAB key and shows a vertical guideline to help you follow the 79-character limit.*

Blank Lines

To group parts of your program visually, use blank lines. You should use blank lines to organize your files, but don't do so excessively. By following the examples provided in this book, you should strike the right balance. For example, if you have five lines of code that build a list and then another three lines that do something with that list, it's appropriate to place a blank line between the two sections. However, you should not place three or four blank lines between the two sections.

Blank lines won't affect how your code runs, but they will affect the readability of your code. The Python interpreter uses horizontal indentation to interpret the meaning of your code, but it disregards vertical spacing.

Other Style Guidelines

PEP 8 has many additional styling recommendations, but most of the guidelines refer to more complex programs than what you're writing at this point. As you learn more complex Python structures, I'll share the relevant parts of the PEP 8 guidelines.

TRY IT YOURSELF

4-14. PEP 8: Look through the original PEP 8 style guide at *https://python.org/dev/peps/pep-0008*. You won't use much of it now, but it might be interesting to skim through it.

4-15. Code Review: Choose three of the programs you've written in this chapter and modify each one to comply with PEP 8.

- Use four spaces for each indentation level. Set your text editor to insert four spaces every time you press the TAB key, if you haven't already done so (see Appendix B for instructions on how to do this).
- Use less than 80 characters on each line, and set your editor to show a vertical guideline at the 80th character position.
- Don't use blank lines excessively in your program files.

Summary

In this chapter, you learned how to work efficiently with the elements in a list. You learned how to work through a list using a `for` loop, how Python uses indentation to structure a program, and how to avoid some common indentation errors. You learned to make simple numerical lists, as well as a few operations you can perform on numerical lists. You learned how to slice a list to work with a subset of items and how to copy lists properly using a slice. You also learned about tuples, which provide a degree of protection to a set of values that shouldn't change, and how to style your increasingly complex code to make it easy to read.

In Chapter 5, you'll learn to respond appropriately to different conditions by using `if` statements. You'll learn to string together relatively complex sets of conditional tests to respond appropriately to exactly the kind of situation or information you're looking for. You'll also learn to use `if` statements while looping through a list to take specific actions with selected elements from a list.