Common Error 3.2

Exact Comparison of Floating-Point Numbers

Floating-point numbers have only a limited precision, and calculations can introduce roundoff errors. You must take these inevitable roundoffs into account when comparing floating-point numbers. For example, the following code multiplies the square root of 2 by itself. Ideally, we expect to get the answer 2:

```
from math import sqrt

r = sqrt(2.0)
if r * r == 2.0 :
   print("sqrt(2.0) squared is 2.0")
else :
   print("sqrt(2.0) squared is not 2.0 but", r * r)
```

Take limited precision into account when comparing floating-point numbers.

This program displays

```
sqrt(2.0) squared is not 2.0 but 2.0000000000000004
```

It does not make sense in most circumstances to compare floating-point numbers exactly. Instead, we should test whether they are *close enough*. That is, the magnitude of their difference should be less than some threshold. Mathematically, we would write that x and y are close enough if

$$|x - y| < \varepsilon$$

for a very small number, ε. ε is the Greek letter epsilon, a letter used to denote a very small quantity. It is common to set ε to 10^{-14} when comparing floating-point numbers:

```
from math import sqrt

EPSILON = 1E-14
r = sqrt(2.0)
if abs(r * r - 2.0) < EPSILON :
   print("sqrt(2.0) squared is approximately 2.0")
```

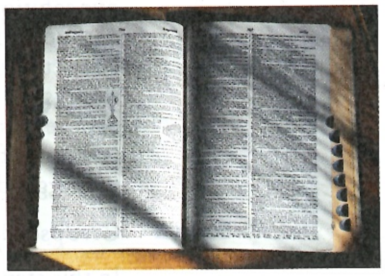
Special Topic 3.2

Lexicographic Ordering of Strings

If two strings are not identical to each other, you still may want to know the relationship between them. Python's relational operators compare strings in "lexicographic" order. This ordering is very similar to the way in which words are sorted in a dictionary. If

```
string1 < string2
```

then the string `string1` comes before the string `string2` in the dictionary. For example, this is the case if `string1` is `"Harry"`, and `string2` is `"Hello"`. If



To see which of two terms comes first in the dictionary, consider the first letter in which they differ.

```
string1 > string2
```

then `string1` comes after `string2` in dictionary order.

As you have seen in the preceding section, if

```
string1 == string2
```

then `string1` and `string2` are equal.

The relational operators compare strings in lexicographic order.

There are a few technical differences between the ordering in a dictionary and the lexicographic ordering in Python.

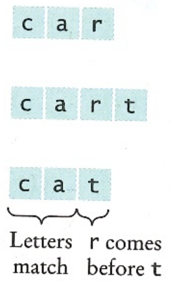
In Python:

- All uppercase letters come before the lowercase letters. For example, `"Z"` comes before `"a"`.
- The space character comes before all printable characters.
- Numbers come before letters.
- For the ordering of punctuation marks, see Appendix A.

When comparing two strings, you compare the first letters of each word, then the second letters, and so on, until one of the strings ends or you find the first letter pair that doesn't match.

If one of the strings ends, the longer string is considered the "larger" one. For example, compare `"car"` with `"cart"`. The first three letters match, and we reach the end of the first string. Therefore `"car"` comes before `"cart"` in the lexicographic ordering.

When you reach a mismatch, the string containing the "larger" character is considered "larger". For example, let's compare `"cat"` with `"cart"`. The first two letters match. Because `t` comes after `r`, the string `"cat"` comes after `"cart"` in the lexicographic ordering.



Lexicographic Ordering

HOW TO 3.1 Implementing an `if` Statement

This How To walks you through the process of implementing an `if` statement.

Problem Statement The university bookstore has a Kilobyte Day sale every October 24, giving an 8 percent discount on all computer accessory purchases if the price is less than \$128, and a 16 percent discount if the price is at least \$128. Write a program that asks the cashier for the original price and then prints the discounted price.

Step 1 Decide upon the branching condition.

In our sample problem, the obvious choice for the condition is:

```
original price < 128?
```

That is just fine, and we will use that condition in our solution.

But you could equally well come up with a correct solution if you choose the opposite condition: Is the original price at least \$128? You might choose this condition if you put yourself into the position of a shopper who wants to know when the bigger discount applies.

Sales discounts are often higher for expensive products. Use the `if` statement to implement such a decision.

Step 2 Give pseudocode for the work that needs to be done when the condition is true.

In this step, you list the action or actions that are taken in the "positive" branch. The details depend on your problem. You may want to print a message, compute values, or even exit the program.

In our example, we need to apply an 8 percent discount:

```
discounted price = 0.92 x original price
```

Step 3 Give pseudocode for the work (if any) that needs to be done when the condition is *not* true.

What do you want to do in the case that the condition of Step 1 is not satisfied? Sometimes, you want to do nothing at all. In that case, use an `if` statement without an `else` branch.