The Practice of Computing Using

PYTHON

William Punch  **Richard Enbody**

Chapter 2

Control

Addison-Wesley
is an imprint of
PEARSON

Control: A Quick Overview

Selection

Selection

- Selection is how programs make choices, and it is the process of making choices that provides a lot of the power of computing

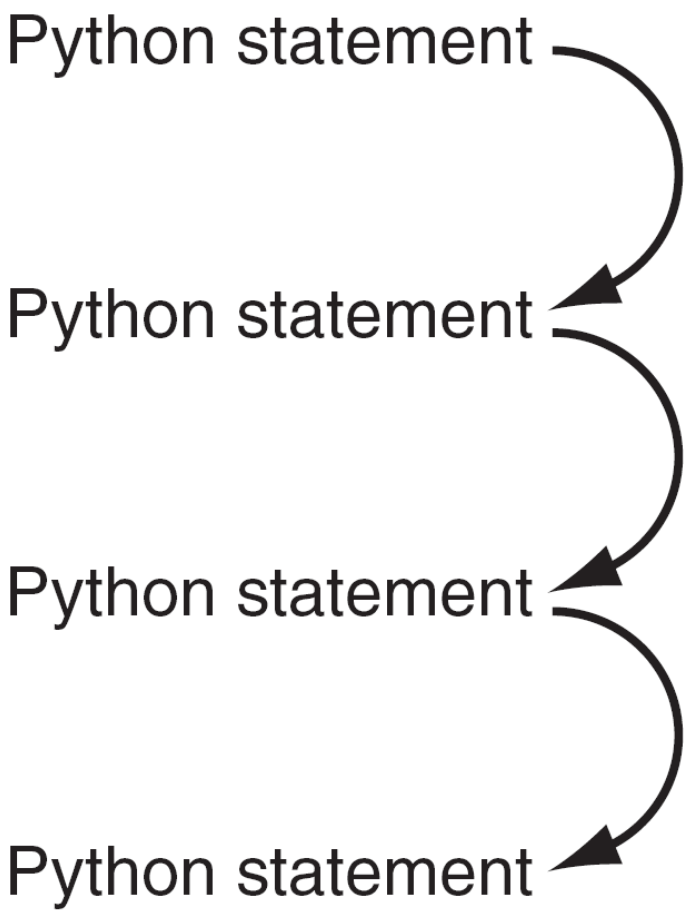


FIGURE 2.1 Sequential program flow.

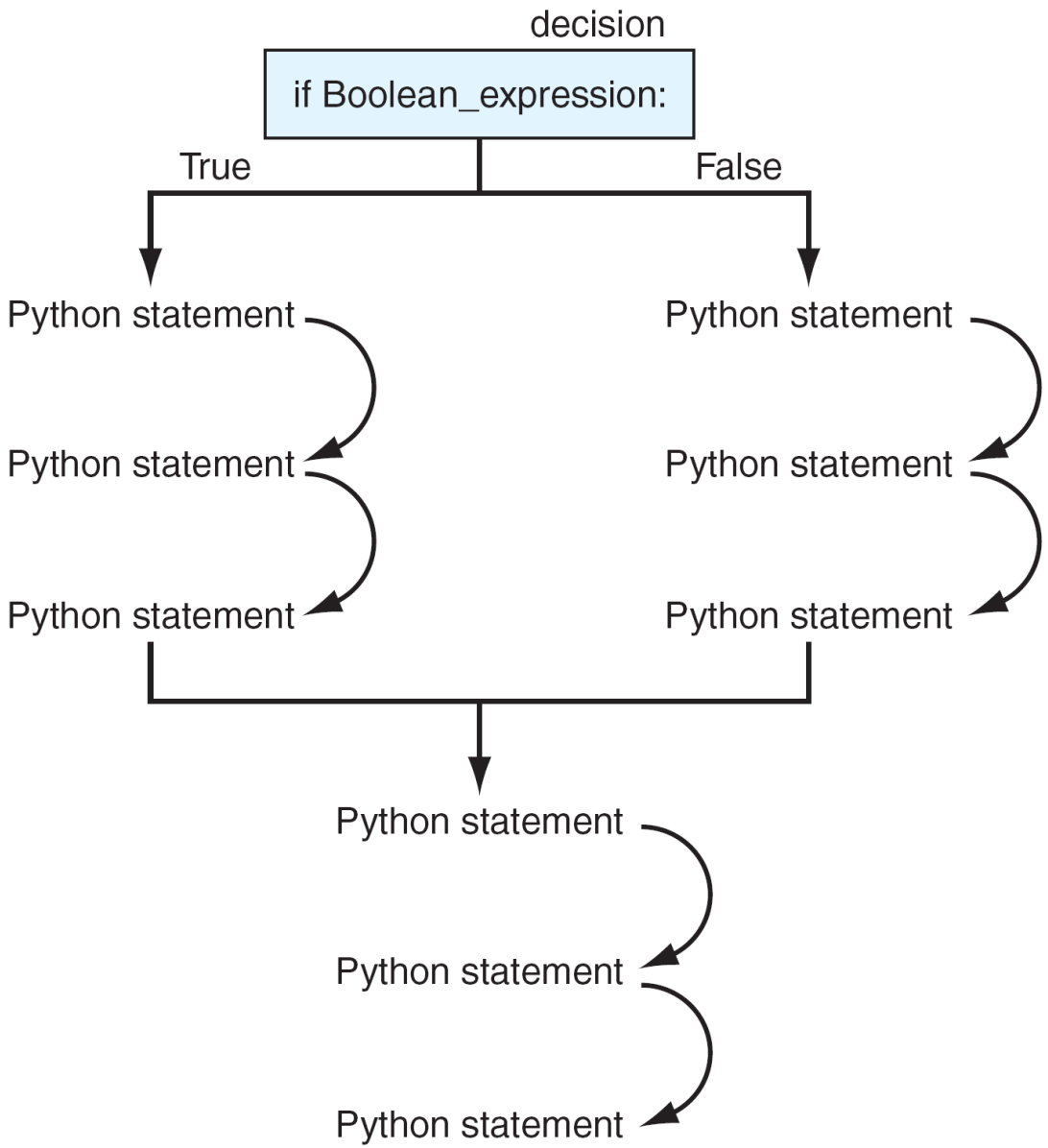


FIGURE 2.2 Decision making flow of control.

Relational Operators

- Less than: <
- Greater than: >
- Equal to: == (Not the same as =)
- Not equal to: !=
- Less than or equal to: <=
- Greater than or equal to: >=

Python if Statement

- if boolean expression :
- suite

- evaluate the boolean (True or False)
- if True, execute all statements in the suite

Warning About Indentation

- Elements of the “suite” must all be indented the same number of spaces/tabs
- Python only recognizes suites when they are indented the same “distance”
- You must be careful to get the indentation right to get suites right.

Python Selection, Round 2

```
if boolean expression:
        suite1
else:
        suite2
```

The process is:

- evaluate the boolean
- if True, run suite1
- if False, run suite2

Safe Lead in Basketball

- Algorithm due to Bill James (www.slate.com)
- under what conditions can you safely determine that a lead in a basketball game is insurmountable?

The Algorithm

- Take the number of points one team is ahead
- Subtract three
- Add ½ point if team that is ahead has the ball, subtract ½ point otherwise
- Square the result
- If the result is greater than the number of seconds left, the lead is safe

```
# 3. Add a half-point if the leading team has the ball,
#    subtract a half-point if the other team has the ball.

has_ball = raw_input("Does the lead team have\
                                the ball (Yes or No): ")

if has_ball == 'Yes':
    points = points + 0.5
else:
    points = points - 0.5
```

```
# 3. Add a half-point if the leading team has the ball,
#    subtract a half-point if the other team has the ball.

has_ball = raw_input("Does the lead team have\
                                    the ball (Yes or No): ")
if has_ball == 'Yes':
    points = points + 0.5
else:
    points = points - 0.5

# numbers less than 0 become 0
if points < 0:
    points = 0
```

```
# 5. If the result is greater than the number of seconds
# left in the game, the lead is safe.
seconds = int(raw_input("Enter the number of\
                        seconds remaining: "))

if points > seconds:
    print "Lead is safe."
else:
    print "Lead is not safe."
```

Repetition: A Quick Overview

Repeating Statements

- Besides selecting which statements to execute, a fundamental need in a program is repetition
  - repeat a set of statements under some conditions
- With both selection and repetition, we have the two most necessary programming statements

While and For Statements

- The while statement is the more general repetition construct. It repeats a set of statements while some condition is True.
- The for statement is useful for iteration, moving through all the elements of data structure, one at a time.

`while` Loop

- Top-tested loop (pretest)
  - test the boolean before running
  - test the boolean before each iteration of the loop

```
while boolean expression:
    statementSuite
```

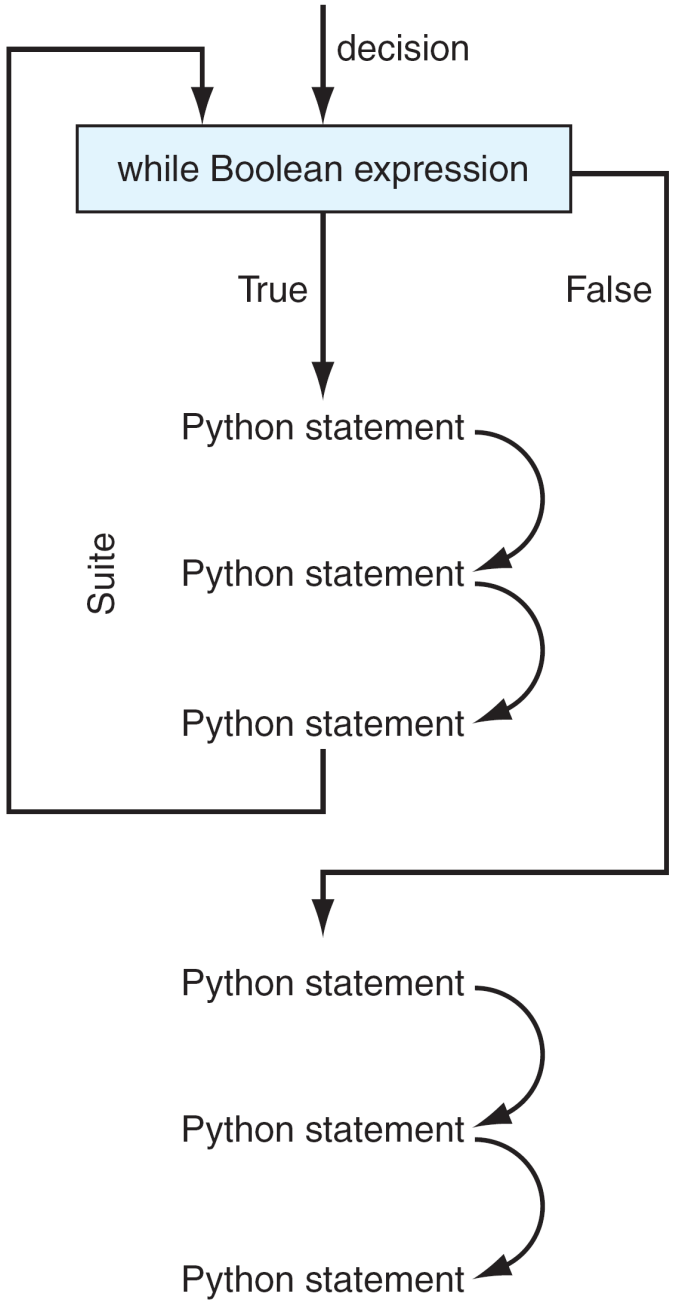


FIGURE 2.3 ***while*** loop.

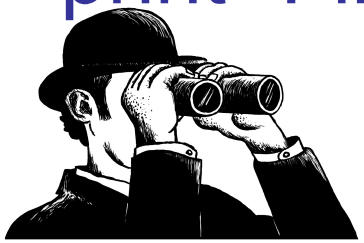
Repeat While the Boolean is True

- while loop will repeat the statements in the suite while the boolean is True (or its Python equivalent)
- If the boolean expression never changes during the course of the loop, the loop will continue forever.

```
# simple while
x_int = 0     # initialize loop-control variable

# test loop-control variable at beginning of loop
while x_int < 10:
    print x_int,          # print x_int each time
    x_int = x_int + 1  # change loop variable

# bigger than value printed in loop!
print
print "Final value of x_int: ", x_int
```



General Approach to a While

- outside the loop, initialize the boolean
- somewhere inside the loop you perform some operation which changes the state of the program, eventually leading to a False boolean and exiting the loop
- Have to have both!

For and Iteration

- One of Python's strength's is it's rich set of built-in data structures
- The for statement is a common statement for manipulation of a data structure
  - for each element in the datastructure
    - perform some operation on that element

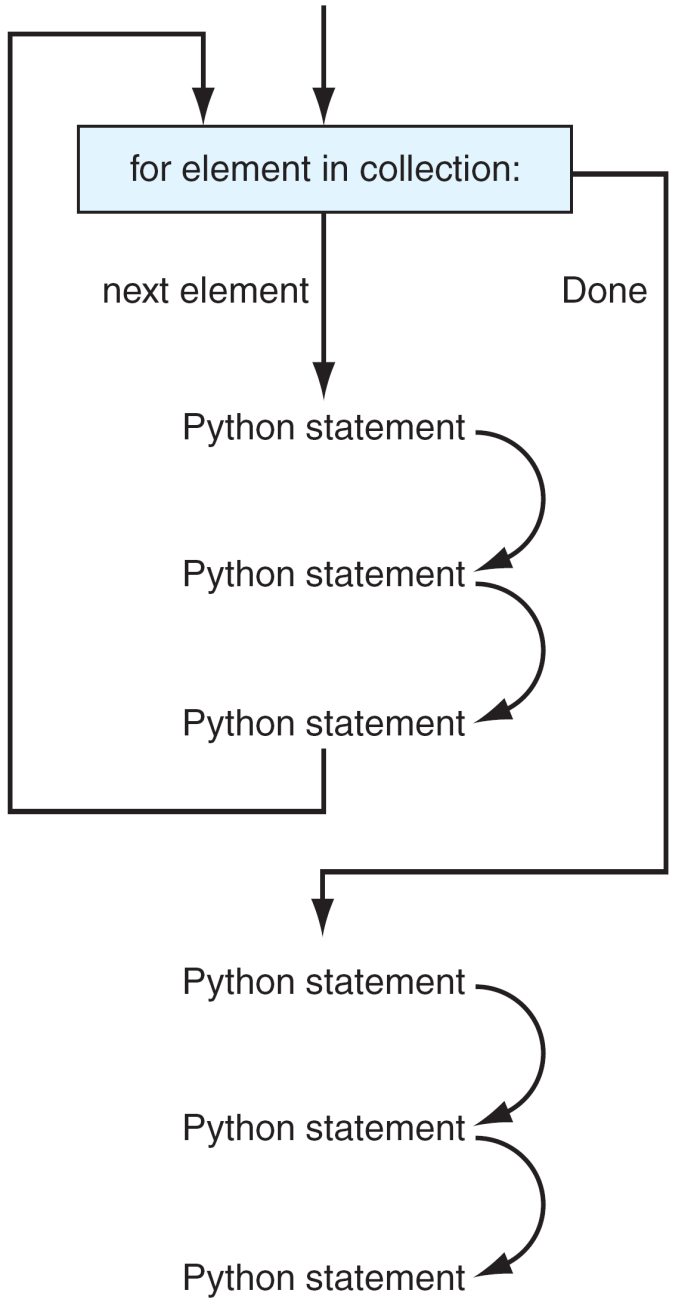


FIGURE 2.4 Operation of a ***for*** loop.

Perfect Number Example

A Perfect Number

- numbers and their factors were mysterious to the Greeks and early mathematicians
- They were curious about the properties of numbers as they held some significance
- A perfect number is a number whose sum of factors (excluding the number) equals the number
- First perfect number is: 6 (1+2+3)

Abundant, Deficient

- abundant numbers summed to more than the number.
  - 12: 1+2+3+4+6 =16
- deficient numbers summed to less than the number.
  - 13: 1

Design

- prompt for a number
- for the number, collect all the factors
- once collected, sum up the factors
- compare the sum and the number and respond accordingly

```
if theNum == sumOfDivisors:
    print theNum,"is perfect"
else:
    print theNum,"is not perfect"
```

Code Listing 2.14
Finding Factors

```
divisor = 1
sumOfDivisors = 0
while divisor < theNum:
    if theNum % divisor==0:   # divisor evenly
                              # divides theNum
        sumOfDivisors = sumOfDivisors + divisor
    divisor = divisor + 1
```

Improving the Perfect Number Program

Work with a range of numbers

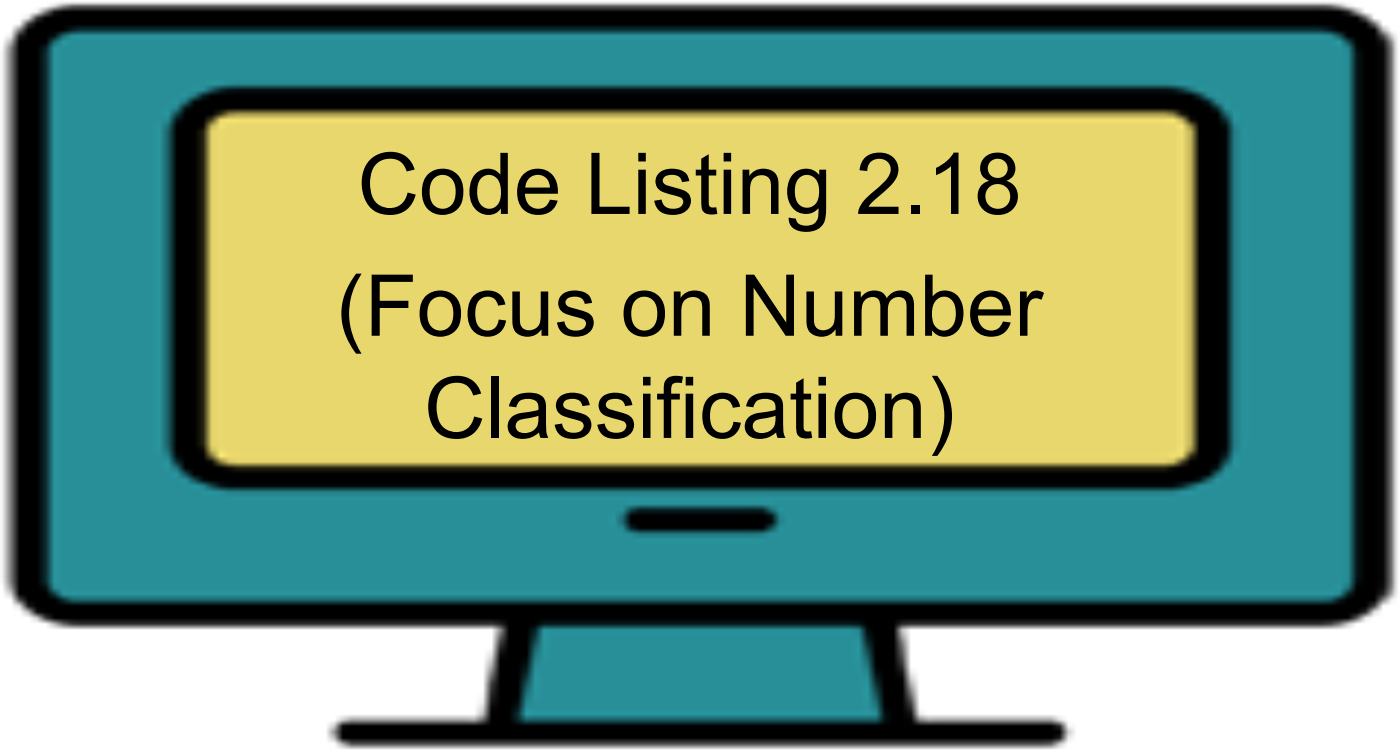
For each number in the range of numbers:

- collect all the factors
- once collected, sum up the factors
- compare the sum and the number and respond accordingly

Print a summary

Code Listing 2.16
Examine a Range of Numbers

```
topNumStr = raw_input("What is the upper\
                                    number for the range:")
topNum = int(topNumStr)
theNum=2
while theNum <= topNum:
    # sum the divisors of theNum
    # classify the number based on its divisor
sum
    theNum += 1
```



```
topNum = raw_input(”Upper range number:")
topNum = int(topNum)
theNum=2
while theNum <= topNum:
   # sum up the divisors, see Code Listing 2.17
   # classify the number based on its divisor sum
    if theNum == sumOfDivisors:
        print theNum,"is perfect"
    if theNum < sumOfDivisors:
        print theNum,"is abundant"
    if theNum > sumOfDivisors:
        print theNum,"is deficient"
    theNum += 1
```

Control In Depth

Booleans

Boolean Expressions

- George Boole's (mid-1800's) mathematics of logical expressions
- Boolean expressions (conditions) have a value of True or False
- Conditions are the basis of choices in a computer, and, hence, are the basis of the appearance of intelligence in them.

What is True, and What is False

- true: any nonzero number or nonempty object. 1, 100, “hello”, [a,b]
- false: a zero number or empty object. 0, “”, [ ]
- Special values called “True” and “False”, which are just standins for 1 and 0. However, they print nicely (True or False)
- Also a special value, “None”, less than everything and equal to nothing

Boolean Expression

- Every boolean expression has the form:
  - expression booleanOperator expression
- The result of evaluating something like the above is also just true or false.
- However, remember what constitutes true or false in Python!

Relational Operators

- In Python 2.x, you can compare different types and get an answer
  - just don't do it! Weird answers (fixed in 3.x)
- Relational Operators have low preference
  - 5 + 3 < 3 – 2
  - 8 < 1
  - False

Examples

- If the value of integer myInt is 5, then the value of expression myInt < 7 is
  - True
- If the value of char myChar is 'A', then the value of expression myChar == 'Q' is
  - False

What Does Equality Mean?

- Two senses of equality
- two variables refer to objects with the same values
- two variables refer to the same object. The id() function used for this.

```
float1 = 2.5
float2  = 2.5
float3  = float2
```

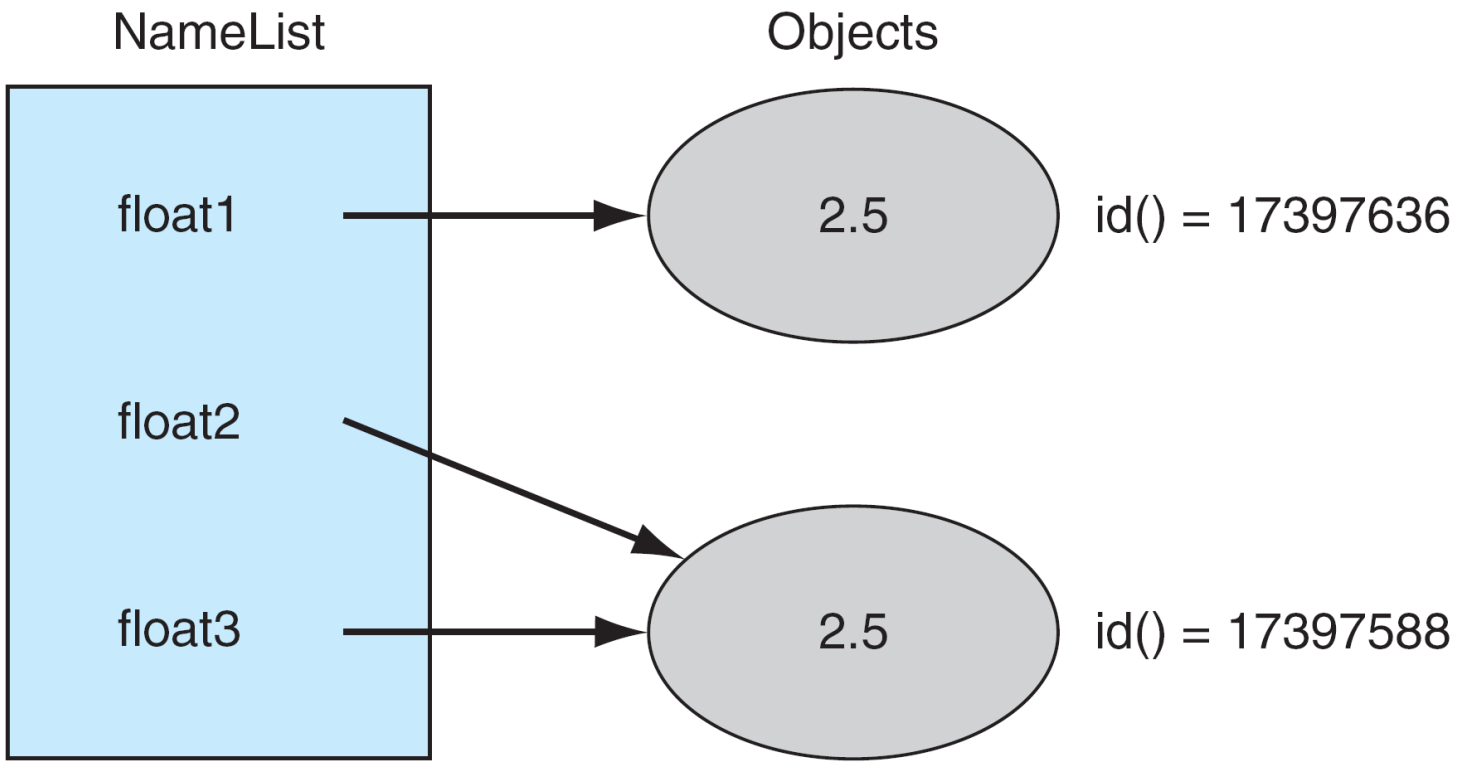


FIGURE 2.5 What is equality?

Chained Comparisons

- In python, chained comparisons work just like you would expect in a mathematical expression:
- Given myInt has the value 5
  - 0 <= myInt <= 5
  - True
  - 0 < myInt <= 5 > 10
  - False

Pitfall

- Be careful of floating point equality comparisons, especially with zero, e.g. myFloat==0. Use the converse “!=“ whenever possible.
- Result = 2/2.0000000000000001
- Result == 1.0
  - True

Compound Expressions

- Logically 0 < X < 3 is actually
  (0 < X) and (X < 3)

- Logical Operators (lower case)
  - and
  - or
  - not

Truth Tables

p	q	not p	p and q	p or q
True	True			
True	False			
False	True			
False	False			

Truth Tables

p	q	not p	p and q	p or q
True	True	False		
True	False	False		
False	True	True		
False	False	True		

Truth Tables

p	q	not p	p and q	p or q
True	True		True	
True	False		False	
False	True		False	
False	False		False	

Truth Tables

p	q	not p	p and q	p or q
True	True			True
True	False			True
False	True			True
False	False			False

Truth Tables

p	q	not p	p and q	p or q
True	True	False	True	True
True	False	False	False	True
False	True	True	False	True
False	False	True	False	False

Compound Evaluation

- Logically 0 < X < 3 is actually
  (0 < X) and (X < 3)
- Evaluate using X with a value of 5:
  (0< X) and (X< 3)
- Parenthesis first: (True) and (False)
- Final value: False

- (Note: parentheses are not necessary in this case.)

Precedence & Associativity

- Relational operators have precedence and associativity just like numerical operators.
- See Table 2.2

Booleans vs. Relationals

- Relational operations always return True or False
- Booleans are different in that:
  - They can return values (that represent True or False)
  - They have “short circuiting”

Remember!

- 0, ‘’,[ ] or other “empty” objects are equivalent to False
- anything else is equivalent to True

Ego Search on Google

- Google search uses Booleans
- by default, all terms are and'ed together
- you can specify or (using OR)
- you can specify not (using -)
- Example is:
  - 'Punch' and ('Bill' or 'William') and not 'gates'

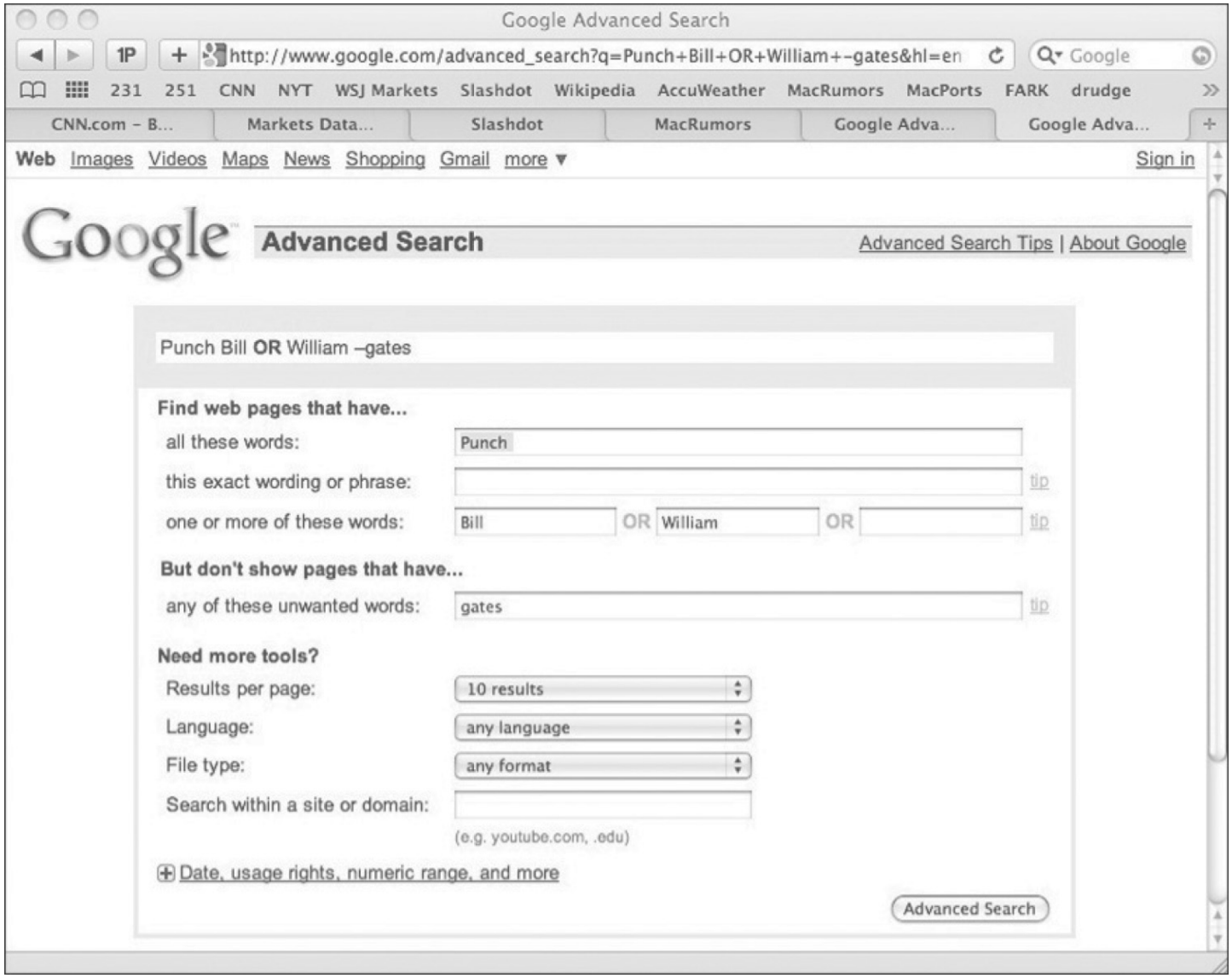
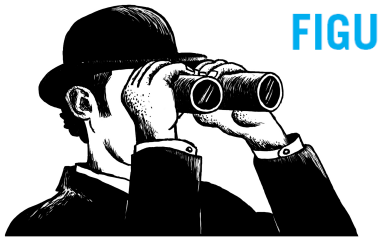


FIGURE 2.7 The Google advanced search page after our egosearch.



More on Assignments

Remember Assignments?

- Format: lhs = rhs
- Behavior:
  - expression in the rhs is evaluated producing a value
  - the value produced is placed in the location indicated on the lhs

Can do Multiple Assignments

- x, y = 2, 3 # assigns x=2 and y=3
- print x, y # prints 2 3

Swap

- Initial values: X is 2, Y is 3
- Behavior: swap values of X and Y
  - Note: X=Y Y=X doesn't work
  - introduce extra variable "temp"
    - temp = X // save X's value in temp
    - X=Y // assign Y's value to X
    - Y=temp // assign temp's value to Y

Swap Using Multiple Assignment

- x, y = 2, 3
  - print x, y # prints 2 3
- x, y = y, x
  - print x, y #prints 3 2

Chaining

- x = y = 5
- print x, y   # prints 5 5

More Control: Selection

Compound Statements

- Compound statements involve a set of statements being used as a group
- Most compound statements have:
  - a header, ending with a ":"
  - a "suite" of statements to be executed
- if, for, while are examples of compound statements

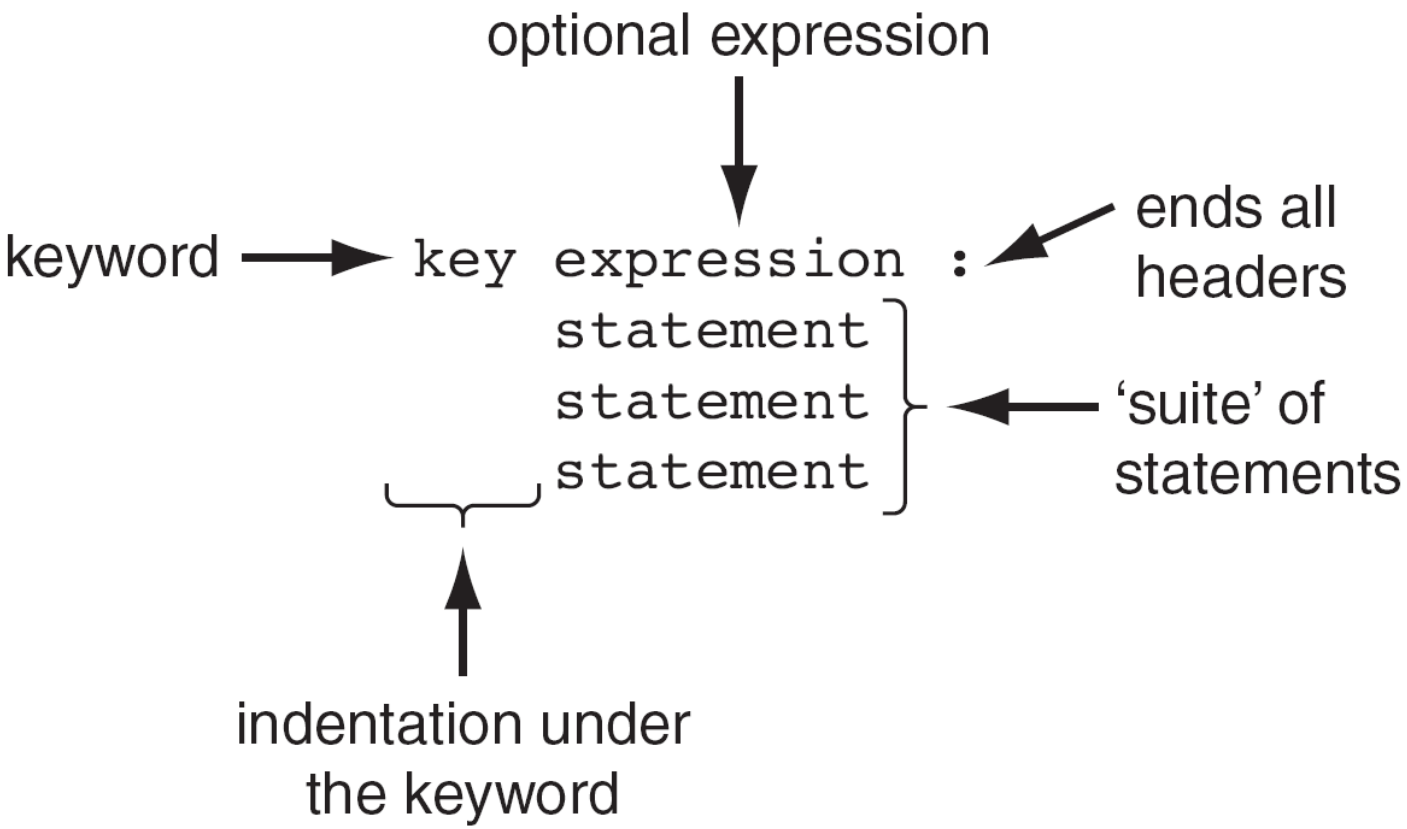


FIGURE 2.8 Control expression.

Have Seen 2 Forms of Selection

```
if boolean expression:
    suite

if boolean expression:
    suite
else:
    suite
```

Python Selection, Round 3

```
if boolean expression1:
        suite1
elif boolean expression2:
        suite2
(as many elif's as you want)
else:
        suiteLast
```

if, elif, else, the Process

- evaluate boolean expressions until:
  - the boolean expression returns True
  - none of the boolean expressions return True
- if a boolean returns True, run the corresponding suite. Skip the rest of the if
- if no boolean returns True, run the else suite, the default suite

```
# classify the number based on its divisor sum
    if theNum == sumOfDivisors:
        print theNum,"is perfect"
    elif theNum < sumOfDivisors:
        print theNum,"is abundant"
    else:
        print theNum,"is deficient"
    theNum += 1
```

More Control: Repetition

While Loop, Round Two

- while loop, oddly, can have an associated else statement
- else statement is executed when the loop finishes under normal conditions
  - basically the last thing the loop does as it exits

While with Else

```
while booleanExpression:
  suite
  suite
else:
  suite
  suite
rest of the program
```

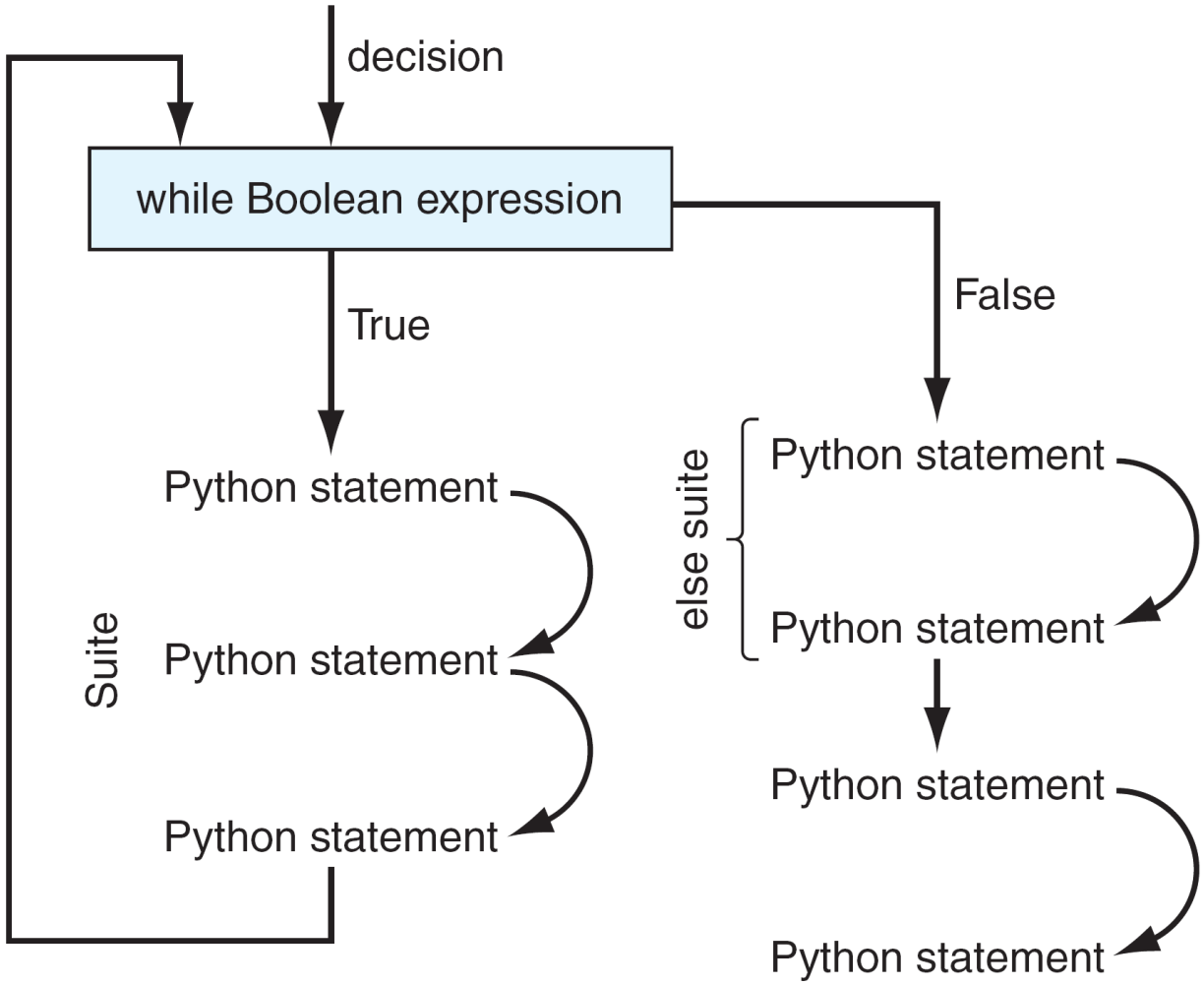
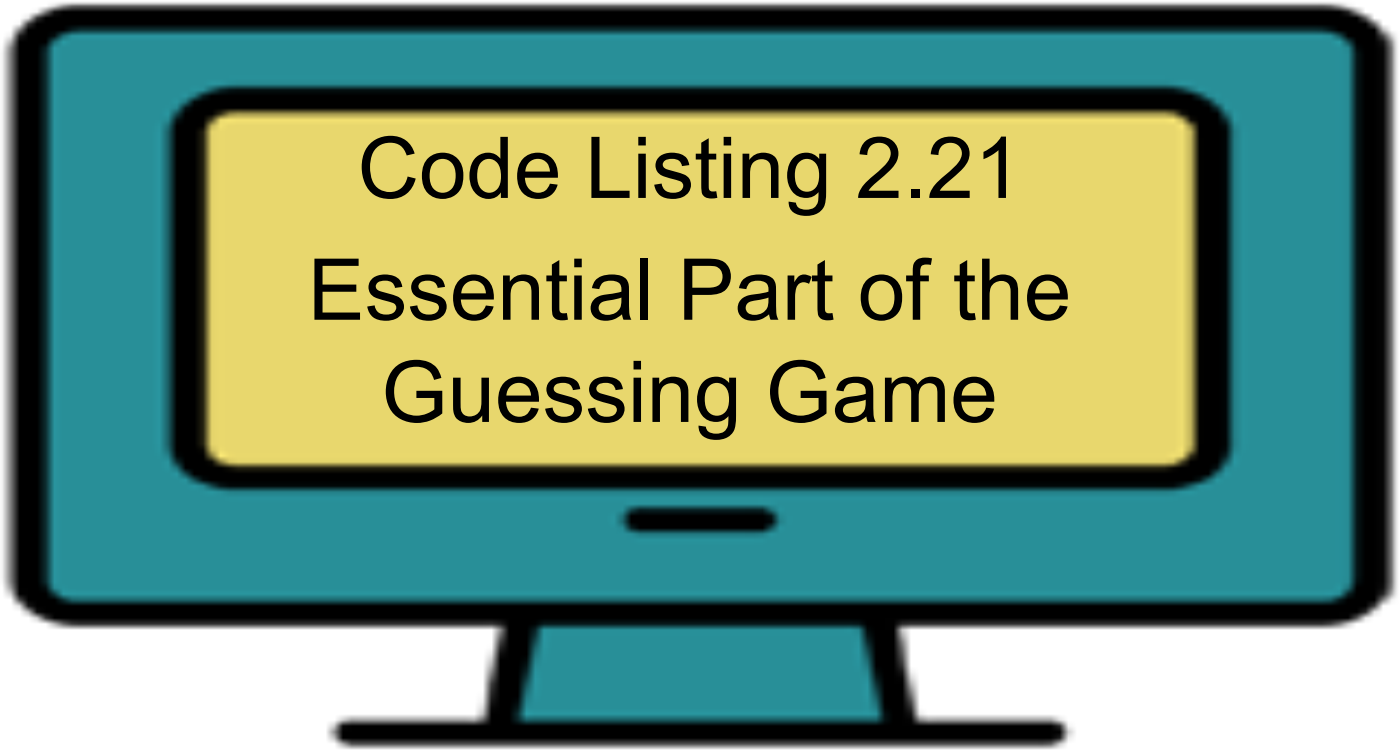


FIGURE 2.9 while-else.

Break Statement

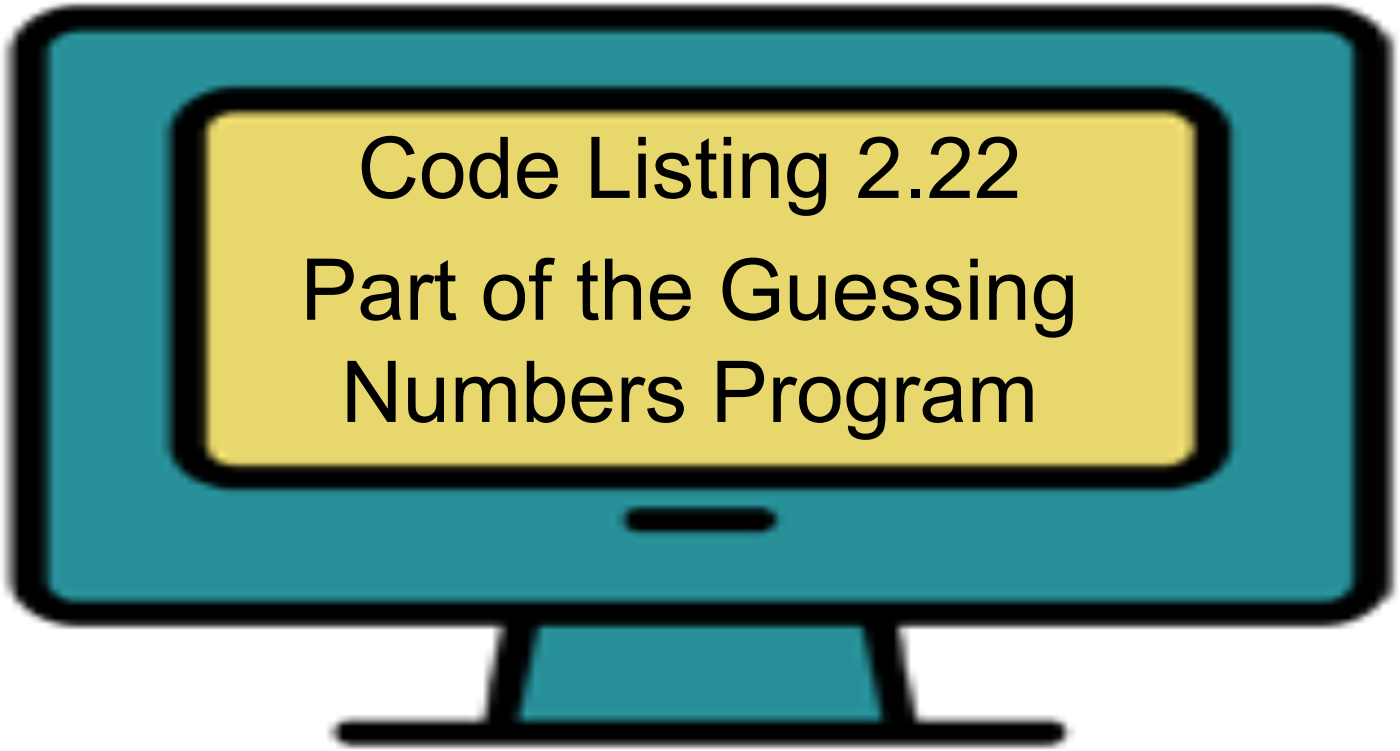
- A break statement in a loop, if executed, exits the loop
- It exists immediately, skipping whatever remains of the loop and the else statement (if it exists) of the loop



```
# while guess is range, keep asking
while 0 <= guess <= 100:
    if guess > number:
        print "Guessed Too High."
    elif guess < number:
        print "Guessed Too Low."
    else:               # correct guess, exit with break
        print "You guessed it. The number was:",number
        break
    # keep going, get the next guess
    guessString = raw_input("Guess a number: ")
    guess = int(guessString)
else:
    print "You quit early, the number was:",number
```

Continue Statement

- A continue statement, if executed in a loop, means to immediately jump back to the top of the loop and re-evaluate the conditional
- Any remaining parts of the loop are skipped for the one iteration when the continue was exectued



```
# Stop if a period (.) is entered
while theNumStr != "." :
    if  not theNumStr.isdigit():        # not a
number, an error
        print "Error, only numbers please"
        theNumStr = raw_input("Number:")
        continue     # if the number is bad, ignore it
    theSum += int(theNumStr)
    theNumStr = raw_input("Number:")
```

Change in Control: Break and Continue

- While loops are easiest read when the conditions of exit are clear
- Excessive use of continue and break within a loop suite make it more difficult to decide when the loop will exit and what parts of the suite will be executed each loop.
- Use them judiciously.

While Overview

```
while test1:
    statement_list_1
    if test2:  break          # Exit loop now; skip else
    if test3:  continue       # Go to top of loop now
    # more statements
else:
    statement_list_2          # If we didn't hit a 'break'

# 'break' or 'continue' lines can appear anywhere
```

Range and for Loop

Range Function

- The range function generates a sequence of integers
- range(5) => [0, 1, 2, 3, 4]
  - assumed to start at 0
  - goes up to, **but does not include**, the provided number argument.
- range(3,10) => [3, 4, 5, 6, 7, 8, 9]
  - first argument is the number to begin with
  - second argument is the end (not included!)

Iterating Through the Sequence

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

- range generates the sequence [1, 2, 3, 4]
- for loop assigns num each of the values in the sequence, one at a time in sequence
- prints each number (one number per line)

Hailstone Example

Collatz

- The Collatz sequence is a simple algorithm applied to any positive integer
- In general, by applying this algorithm to your starting number you generate a sequence of other positive numbers, ending at 1
- Unproven whether every number ends in 1 (though strong evidence exists)

Algorithm

while the number does not equal one

- If the number is odd, multiply by 3 and add 1
- If the number is even, divide by 2
- Use the new number and reapply the algorithm

Even and Odd

Use the remainder operator

- if num % 2 == 0: # even
- if num % 2 == 1: # odd
- if num %2: # odd (why???)

Code Listing 2.26
Hailstone Sequence, Loop

```
while num > 1:  # stop when the sequence reaches 1
    if num%2:        # num is odd
        num = num*3 + 1
    else:            # num is even
        num = num/2
    print num,",",   # add num to sequence

    count +=1        # add to the count


else:
    print    # blank line for nicer output
    print "Sequence is ",count," numbers long"
```