Building Java Programs

Chapter 5
Lecture 5-1: while Loops, Fencepost Loops, and Sentinel Loops

reading: 5.1 – 5.2
while (mahself.stillAwake())
{
    sheep++;
}

A deceptive problem...

- Write a method `printLetters` that prints each letter from a word separated by commas.

For example, the call:

```
printLetters("Atmosphere")
```

should print:

```
A, t, m, o, s, p, h, e, r, e
```
Flawed solutions

• public static void printLetters(String word) {
    for(int i = 0; i < word.length(); i++) {
        System.out.print(word.charAt(i) + "", ");
    }
    System.out.println(); // end line
}
• Output: A, t, m, o, s, p, h, e, r, e,

• public static void printLetters(String word) {
    for(int i = 0; i < word.length(); i++) {
        System.out.print("", " + word.charAt(i));
    }
    System.out.println(); // end line
}
• Output: , A, t, m, o, s, p, h, e, r, e
Fence post analogy

- We print $n$ letters but need only $n - 1$ commas.
- Similar to building a fence with wires separated by posts:
  - If we use a flawed algorithm that repeatedly places a post + wire, the last post will have an extra dangling wire.

```plaintext
for (length of fence) {
    place a post.
    place some wire.
}
```
Fencepost loop

- Add a statement outside the loop to place the initial "post."
- Also called a fencepost loop or a "loop-and-a-half" solution.

```java
place a post.
for (length of fence - 1) {
    place some wire.
    place a post.
}
```
Fencepost method solution

- public static void printLetters(String word) {
  
  System.out.print(word.charAt(0));
  for(int i = 1; i < word.length(); i++) {
    System.out.print("", " + word.charAt(i));
  }
  System.out.println(); // end line
}

- Alternate solution: Either first or last "post" can be taken out:

  public static void printLetters(String word) {
    for(int i = 0; i < word.length() - 1; i++) {
      System.out.print(word.charAt(i) + ", ");
    }
    int last = word.length() - 1;
    System.out.println(word.charAt(last)); // end line
  }
• Write a method `printPrimes` that prints all *prime* numbers up to a max.
  
  • Example: `printPrimes(50)` prints
    
    `2, 3, 5, 7, 11, 13, 17, 19, 23, 29, 31, 37, 41, 43, 47`
  
  • If the maximum is less than 2, print no output.

• To help you, write a method `countFactors` which returns the number of factors of a given integer.
  
  • `countFactors(20)` returns 6 due to factors `1, 2, 4, 5, 10, 20`. 
// Prints all prime numbers up to the given max.
public static void printPrimes(int max) {
    if (max >= 2) {
        System.out.print("2");
        for (int i = 3; i <= max; i++) {
            if (countFactors(i) == 2) {
                System.out.print("", " + i);
            }
        }
        System.out.println();
    }
}

// Returns how many factors the given number has.
public static int countFactors(int number) {
    int count = 0;
    for (int i = 1; i <= number; i++) {
        if (number % i == 0) {
            count++;
            // i is a factor of number
        }
    }
    return count;
}
while loops

reading: 5.1
Categories of loops

- **definite loop**: Executes a known number of times.
  - The *for* loops we have seen are definite loops.
    - Print "hello" 10 times.
    - Find all the prime numbers up to an integer \( n \).
    - Print each odd number between 5 and 127.

- **indefinite loop**: One where the number of times its body repeats is not known in advance.
  - Prompt the user until they type a non-negative number.
  - Print random numbers until a prime number is printed.
  - Repeat until the user has typed "q" to quit.
The **while** loop

- **while loop**: Repeatedly executes its body as long as a logical test is true.

  ```java
  while (test) {
    statement(s);
  }
  ```

- **Example:**

  ```java
  int num = 1; // initialization
  while (num <= 200) { // test
    System.out.print(num + " ");
    num = num * 2; // update
  }
  // output: 1 2 4 8 16 32 64 128
  ```
Example while loop

// finds the first factor of 91, other than 1
int n = 91;
int factor = 2;
while (n % factor != 0) {
    factor++;
}
System.out.println("First factor is " + factor);
// output: First factor is 7

• while is better than for because we don't know how many times we will need to increment to find the factor.
Sentinel values

- **sentinel**: A value that signals the end of user input.
  - **sentinel loop**: Repeats until a sentinel value is seen.

- Example: Write a program that prompts the user for text until the user types nothing, then output the total number of characters typed.
  - (In this case, the *empty* string is the sentinel value.)

```
Type a line (or nothing to exit): hello
Type a line (or nothing to exit): this is a line
Type a line (or nothing to exit):
You typed a total of 19 characters.
```
Solution?

Scanner console = new Scanner(System.in);
int sum = 0;
String response = "dummy"; // "dummy" value, anything but ""

while (!response.equals("")) {
    System.out.print("Type a line (or nothing to exit): ");
    response = console.nextLine();
    sum += response.length();
}

System.out.println("You typed a total of " + sum + " characters.");
Changing the sentinel value

- Modify your program to use "quit" as the sentinel value.
- Example log of execution:

  Type a line (or "quit" to exit): hello
  Type a line (or "quit" to exit): this is a line
  Type a line (or "quit" to exit): quit
  You typed a total of 19 characters.
Changing the sentinel value

• Changing the sentinel's value to "quit" does not work!

    Scanner console = new Scanner(System.in);
    int sum = 0;
    String response = "dummy";  // "dummy" value, anything but "quit"

    while (!response.equals("quit")) {
        System.out.print("Type a line (or \"quit\" to exit): ");
        response = console.nextLine();
        sum += response.length();
    }

    System.out.println("You typed a total of " + sum + " characters.");

• This solution produces the wrong output. Why?
  You typed a total of 23 characters.
The problem with our code

- Our code uses a pattern like this:
  
  ```
  sum = 0.
  while (input is not the sentinel) {
    prompt for input; read input.
    add input length to the sum.
  }
  
  On the last pass, the sentinel’s length (4) is added to the sum:
  
  prompt for input; read input ("quit").
  add input length (4) to the sum.
  ```

- This is a fencepost problem.
  - Must read $N$ lines, but only sum the lengths of the first $N-1$. 
A fencepost solution

\[ \text{sum} = 0. \]

\textit{prompt for input; read input.} \quad // \text{place a "post"}

\textbf{while} (\textit{input is not the sentinel}) \{ \\
\textit{add input length to the sum.} \quad // \text{place a "wire"} \\
\textit{prompt for input; read input.} \quad // \text{place a "post"}
\}

- Sentinel loops often utilize a fencepost "loop-and-a-half" style solution by pulling some code out of the loop.
Correct code

Scanner console = new Scanner(System.in);
int sum = 0;

// pull one prompt/read ("post") out of the loop
System.out.print("Type a line (or \"quit\" to exit): ");
String response = console.nextLine();

while (!response.equals("quit")) {
    sum += response.length();    // moved to top of loop
    System.out.print("Type a line (or \"quit\" to exit): ");
    response = console.nextLine();
}

System.out.println("You typed a total of " + sum + " characters.");
Sentinel as a constant

```java
public static final String SENTINEL = "quit";
...

Scanner console = new Scanner(System.in);
int sum = 0;

// pull one prompt/read ("post") out of the loop
System.out.print("Type a line (or " + SENTINEL + "\" to exit): ");
String response = console.nextLine();

while (!response.equals(SENTINEL)) {
    sum += response.length();  // moved to top of loop
    System.out.print("Type a line (or " + SENTINEL + "\" to exit): ");
    response = console.nextLine();
}
System.out.println("You typed a total of " + sum + " characters.");
```
public static final String SENTINEL = "quit";

public static void main(String[] args) {
    Scanner console = new Scanner(System.in);
    int sum = 0;

    // pull one prompt/read ("post") out of the loop
    String response = getLine(console);

    while (!response.equals(SENTINEL)) {
        sum += response.length();  // moved to top of loop
        response = getLine(console);
    }

    System.out.println("You typed a total of " + sum + " characters.");
}

public static String getLine(Scanner console) {
    System.out.print("Type a line (or " + SENTINEL + ") to exit): ");
    return console.nextLine();
}