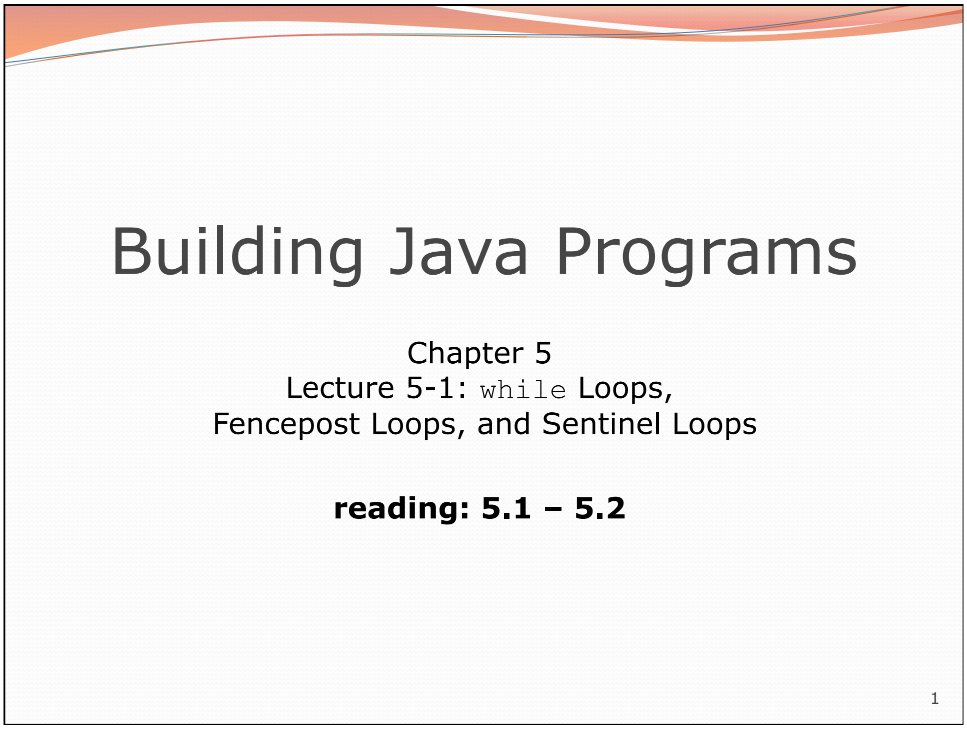
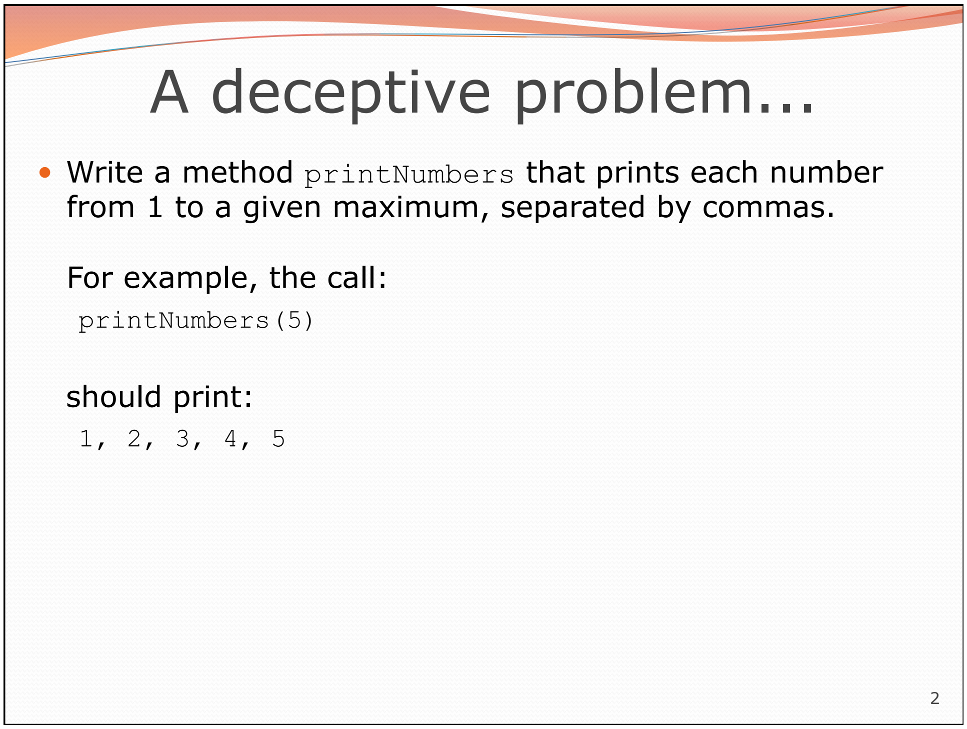


Building Java Programs

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

reading: 5.1 – 5.2



A deceptive problem...

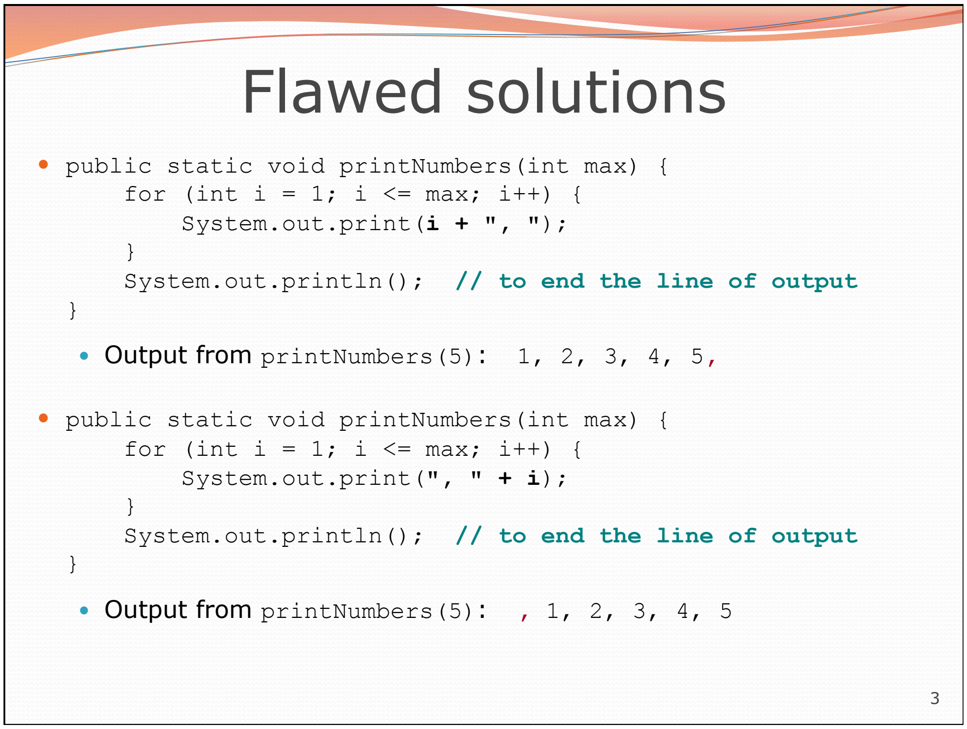
- Write a method `printNumbers` that prints each number from 1 to a given maximum, separated by commas.

  For example, the call:

  ```
  printNumbers(5)
  ```

  should print:

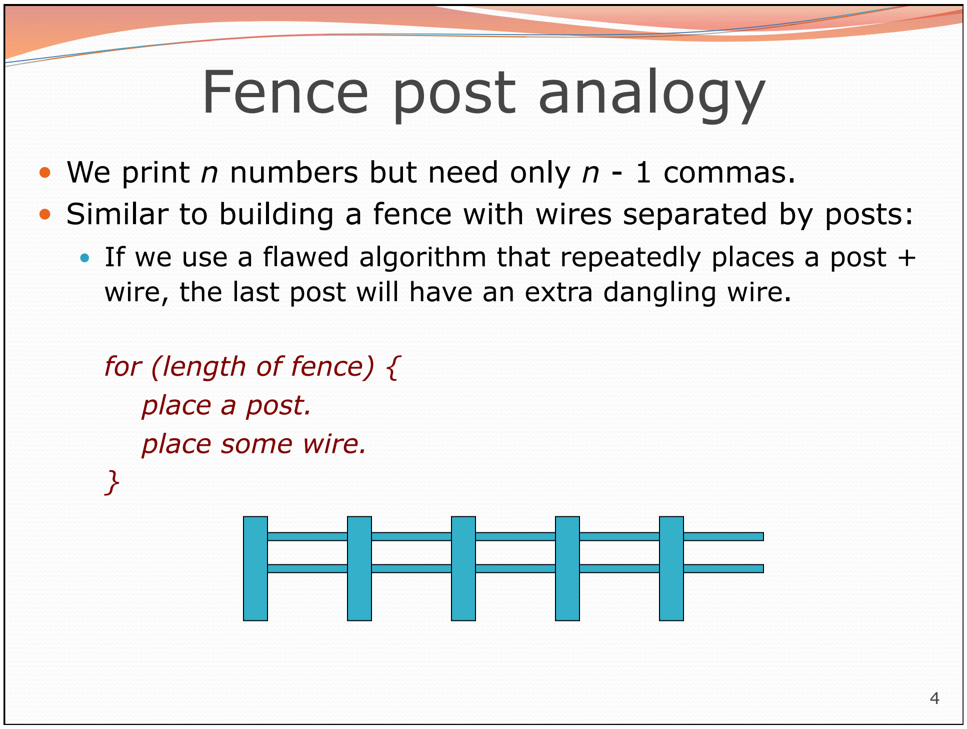
  ```
  1, 2, 3, 4, 5
  ```



Flawed solutions

-
  ```
  public static void printNumbers(int max) {
      for (int i = 1; i <= max; i++) {
          System.out.print(i + ", ");
      }
      System.out.println();  // to end the line of output
  }
  ```
  - Output from `printNumbers(5)`: `1, 2, 3, 4, 5,`

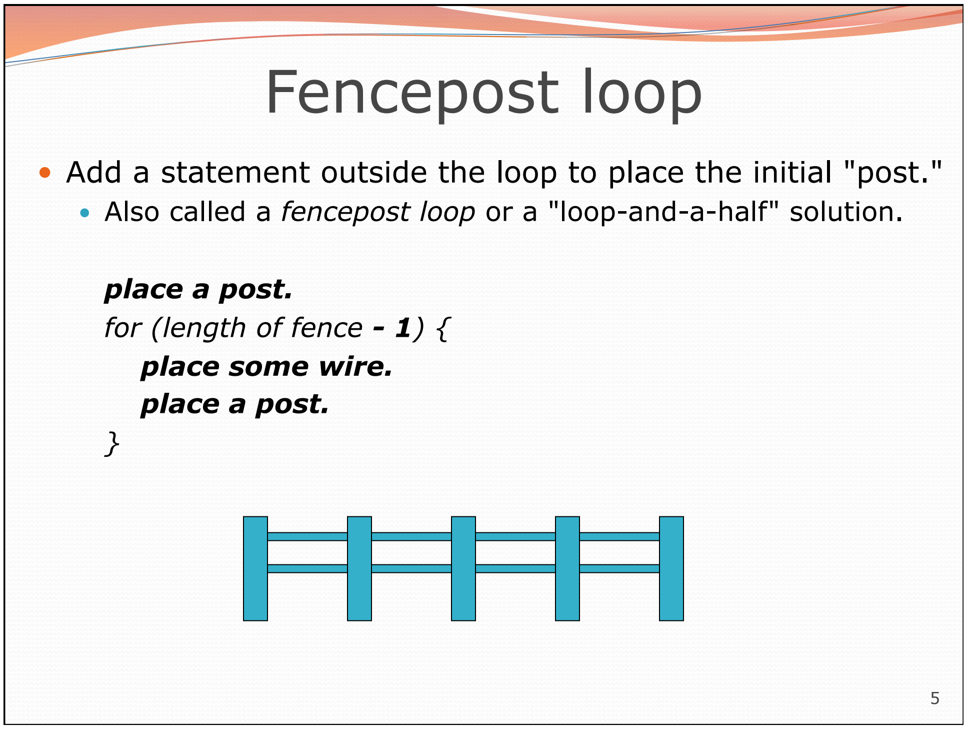
-
  ```
  public static void printNumbers(int max) {
      for (int i = 1; i <= max; i++) {
          System.out.print(", " + i);
      }
      System.out.println();  // to end the line of output
  }
  ```
  - Output from `printNumbers(5)`: `, 1, 2, 3, 4, 5`



Fence post analogy

- We print *n* numbers 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.

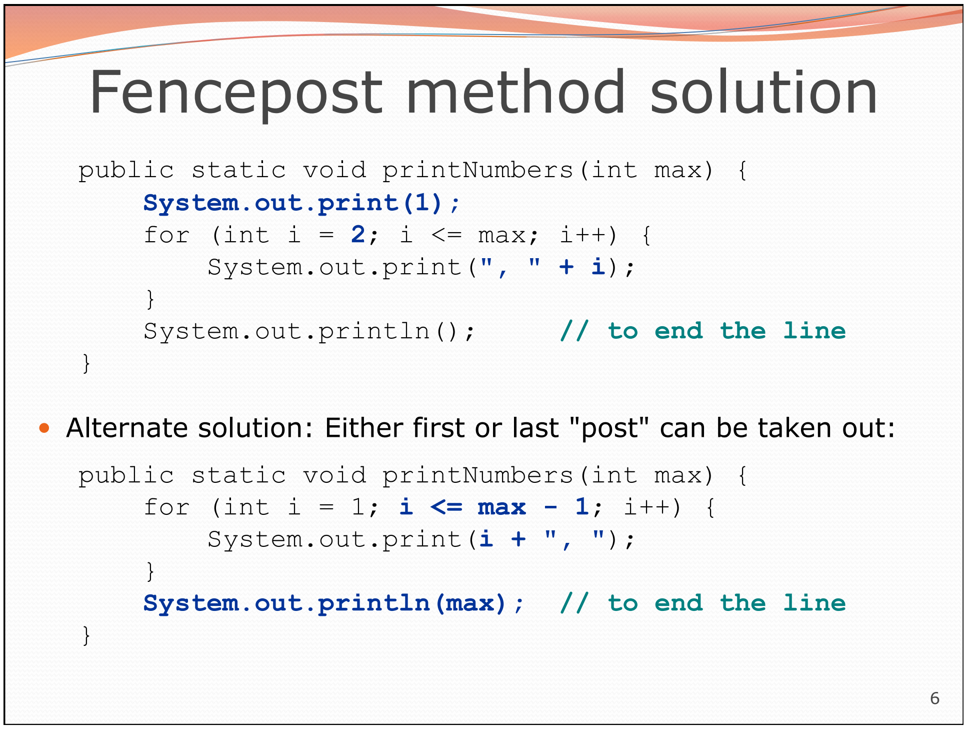
```
for (length of fence) {
    place a post.
    place some wire.
}
```



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.

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

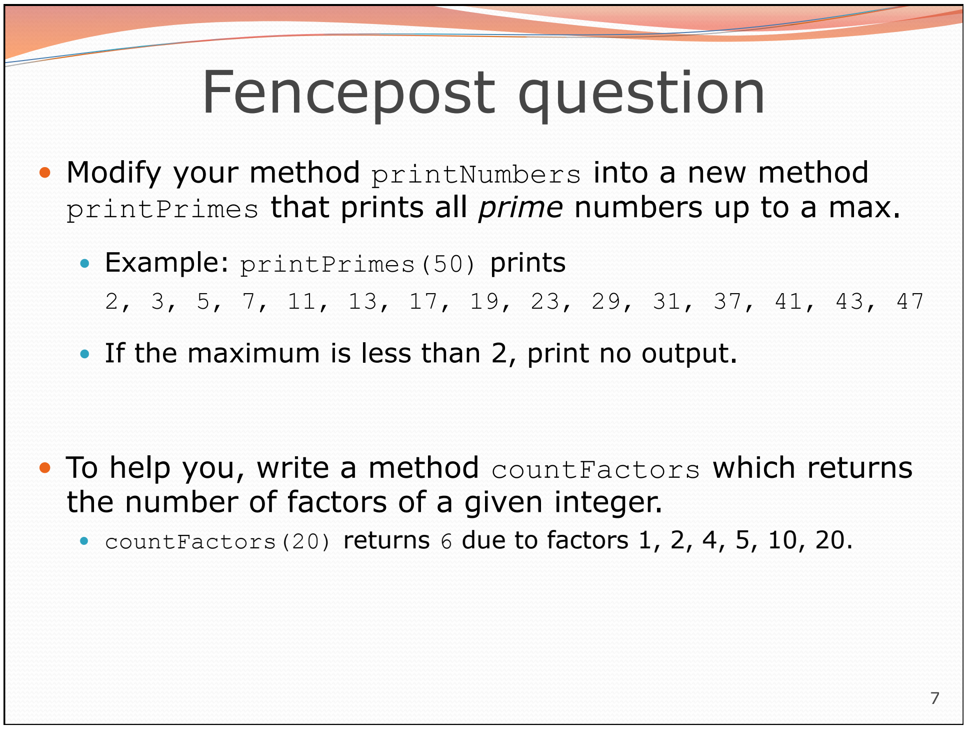


Fencepost method solution

```
public static void printNumbers(int max) {
    System.out.print(1);
    for (int i = 2; i <= max; i++) {
        System.out.print(", " + i);
    }
    System.out.println();     // to end the line
}
```

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

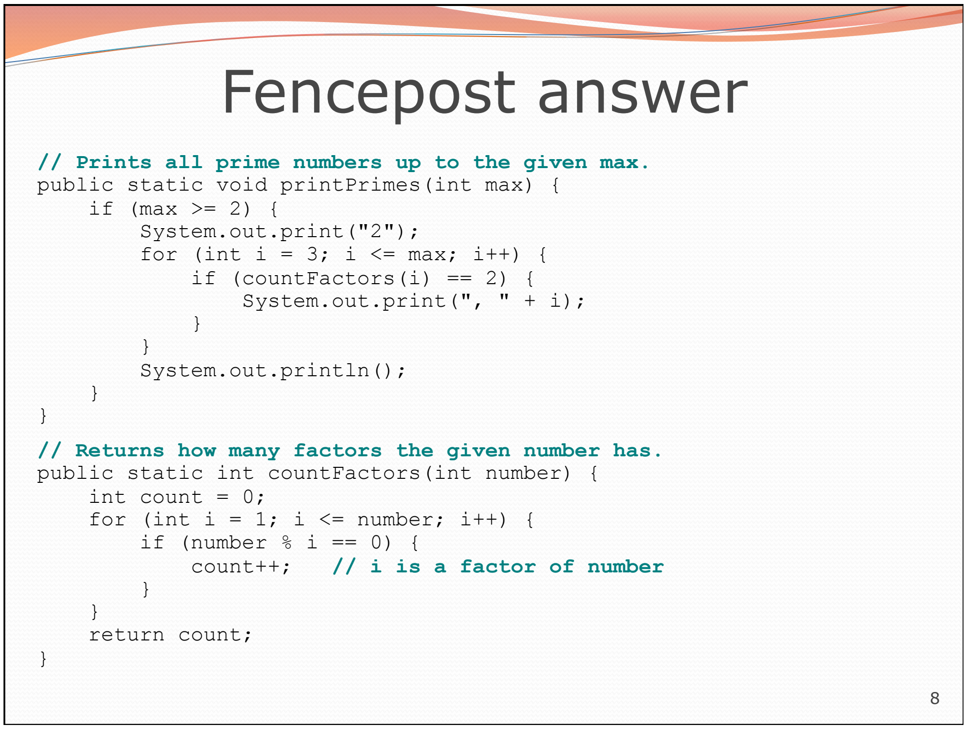
```
public static void printNumbers(int max) {
    for (int i = 1; i <= max - 1; i++) {
        System.out.print(i + ", ");
    }
    System.out.println(max);  // to end the line
}
```



Fencepost question

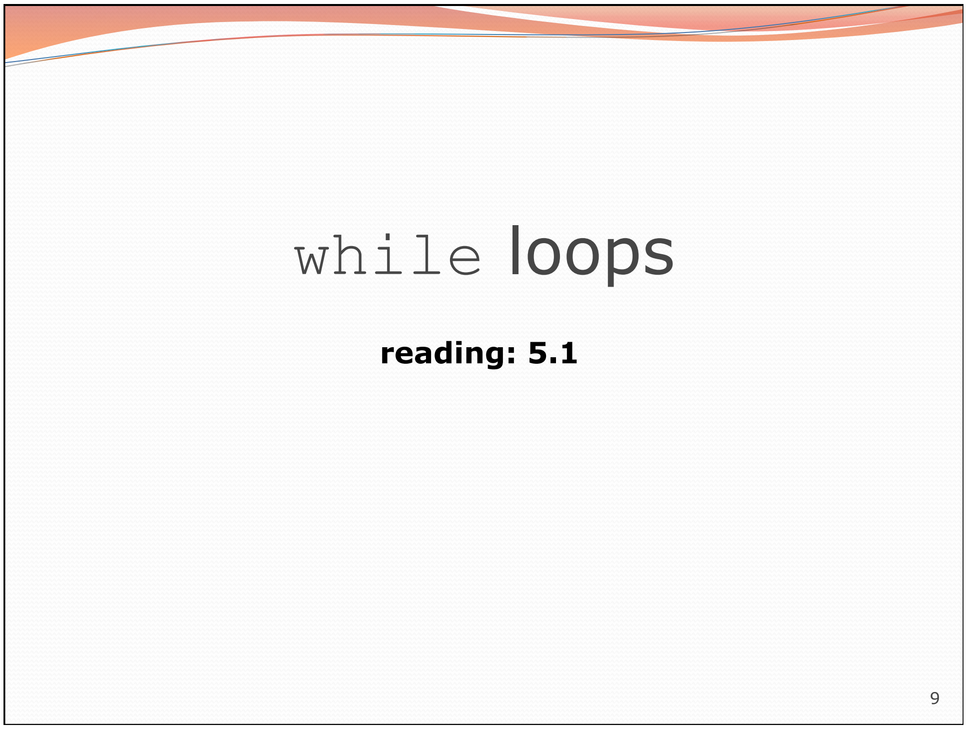
- Modify your method `printNumbers` into a new method `printPrimes` that prints all *prime* numbers up to a max.
  - Example: `printPrimes(50)` prints
    `2, 3, 5, 7, 11, 13, 17, 19, 23, 29, 31, 37, 41, 43, 47`
  - If the maximum is less than 2, print no output.

- 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.



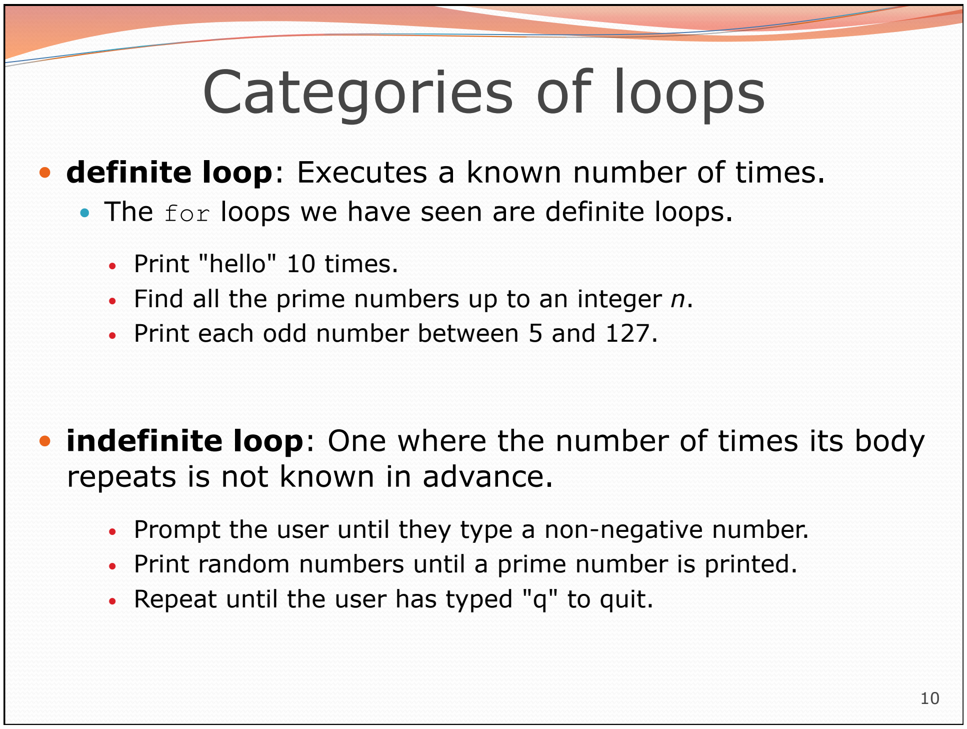
Fencepost answer

```
// 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

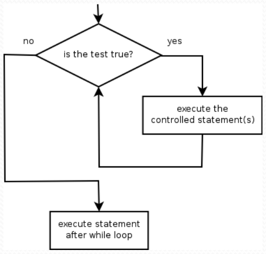
- **definite loop**: Executes a known number of times.
  - The `for` loops we have seen are definite loops.
    - Print "hello" 10 times.
    - Find all the prime numbers up to an integer *n*.
    - Print each odd number between 5 and 127.

- **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.

```
while (<test>) {
    <statement(s)>;
}
```


no
yes
is the test true?
execute the controlled statement(s)
execute statement after while loop

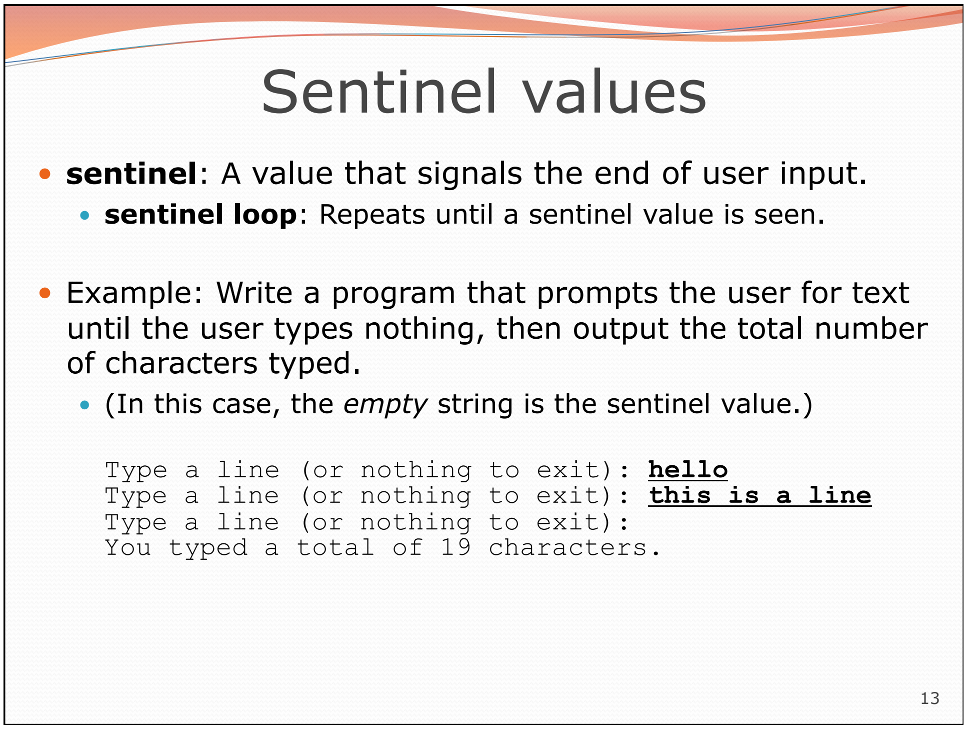
- Example:

```
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.

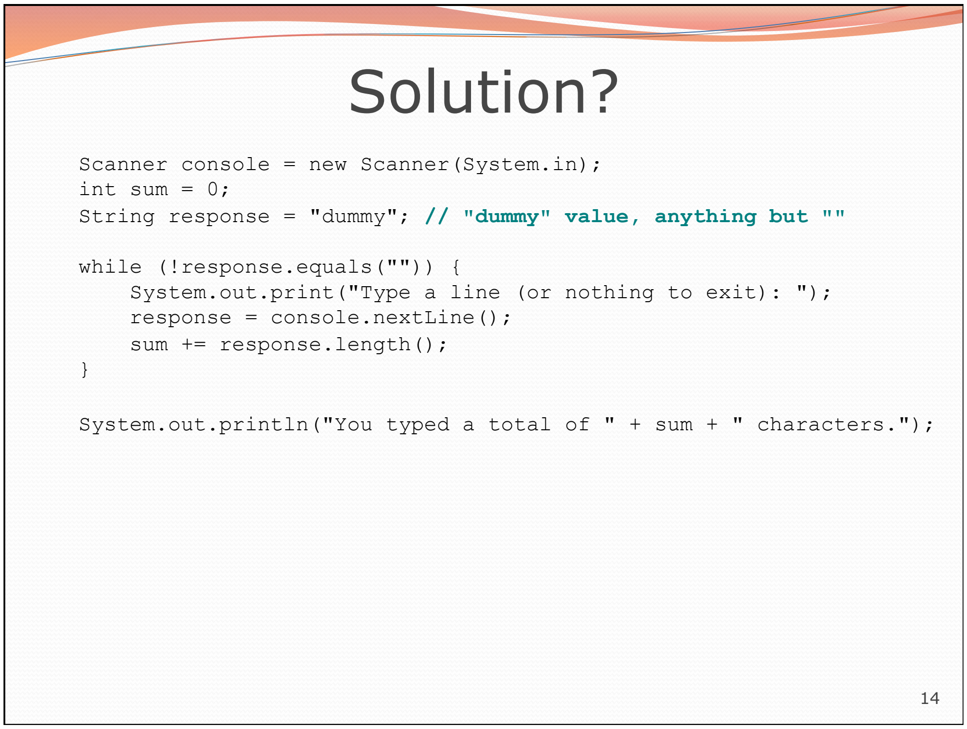


Sentinel values

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

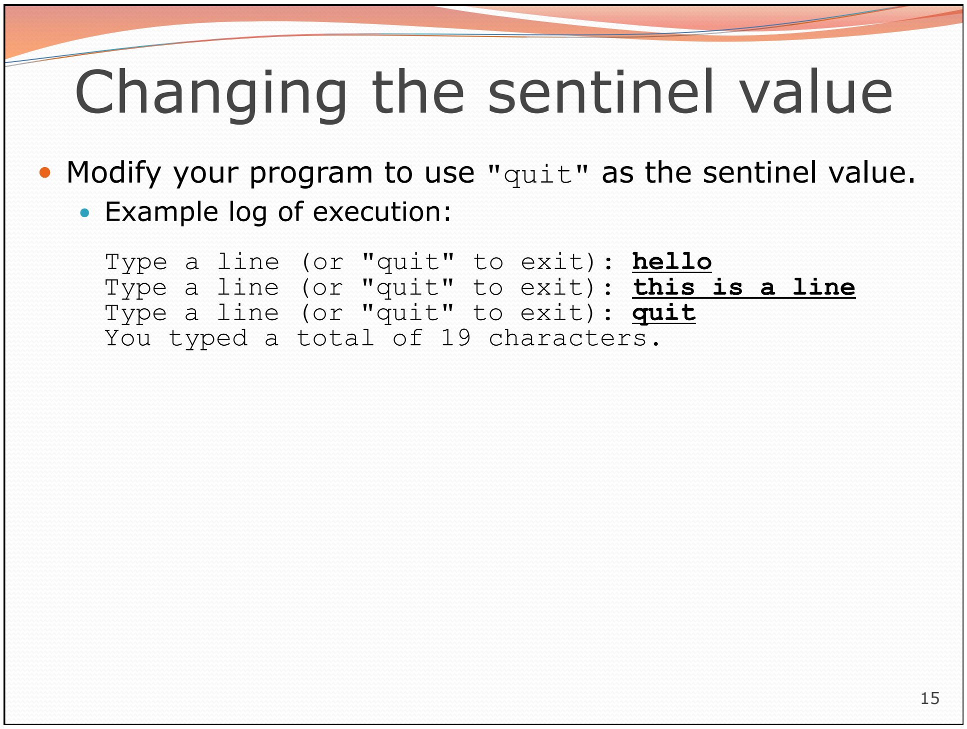
- Example: Write a program that prompts the user for text until the user types nothing, then output the total number of characters typed.
  - (In this case, the *empty* string is the sentinel value.)

```
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?

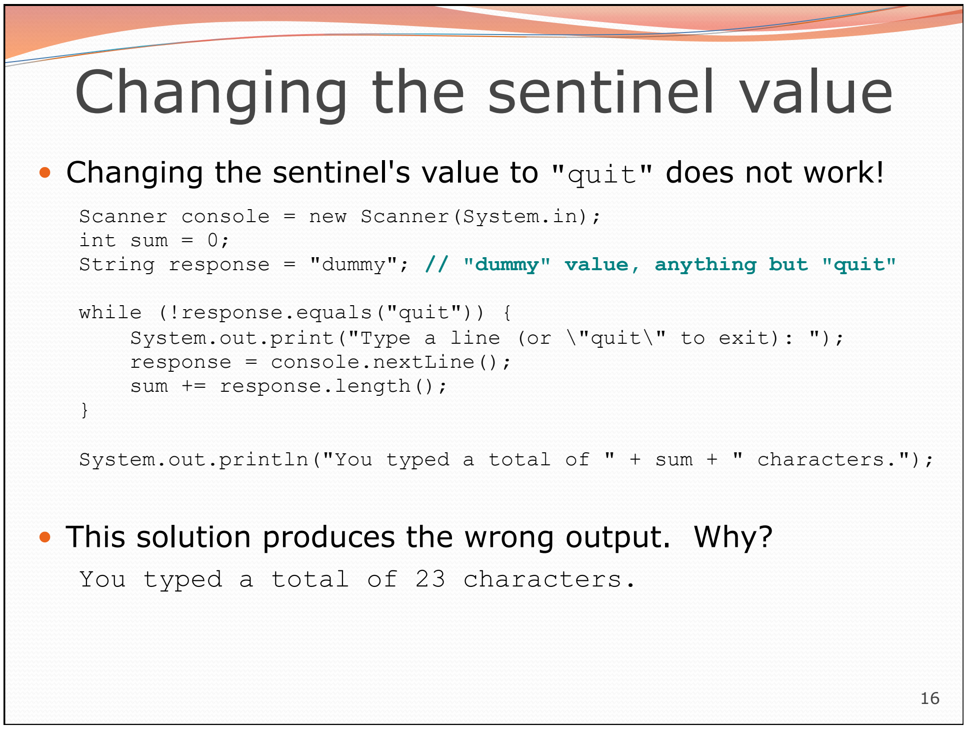
```
Scanner console = new Scanner(System.in);
int sum = 0;
String response = "dummy"; // "dummy" value, anything but ""

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.
```



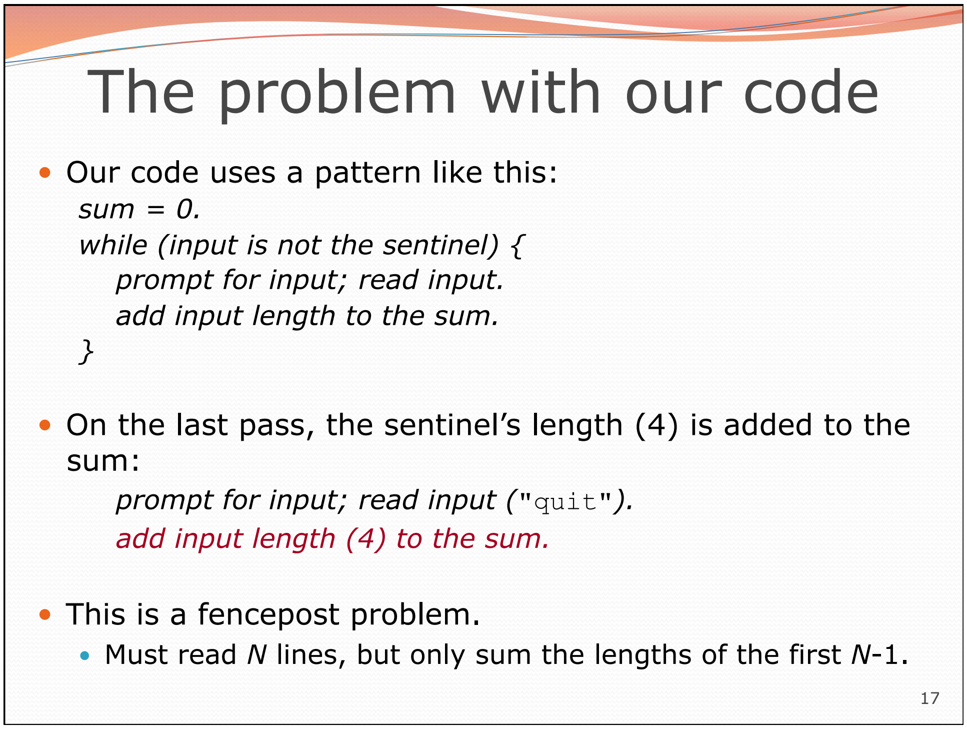
Changing the sentinel value

- 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

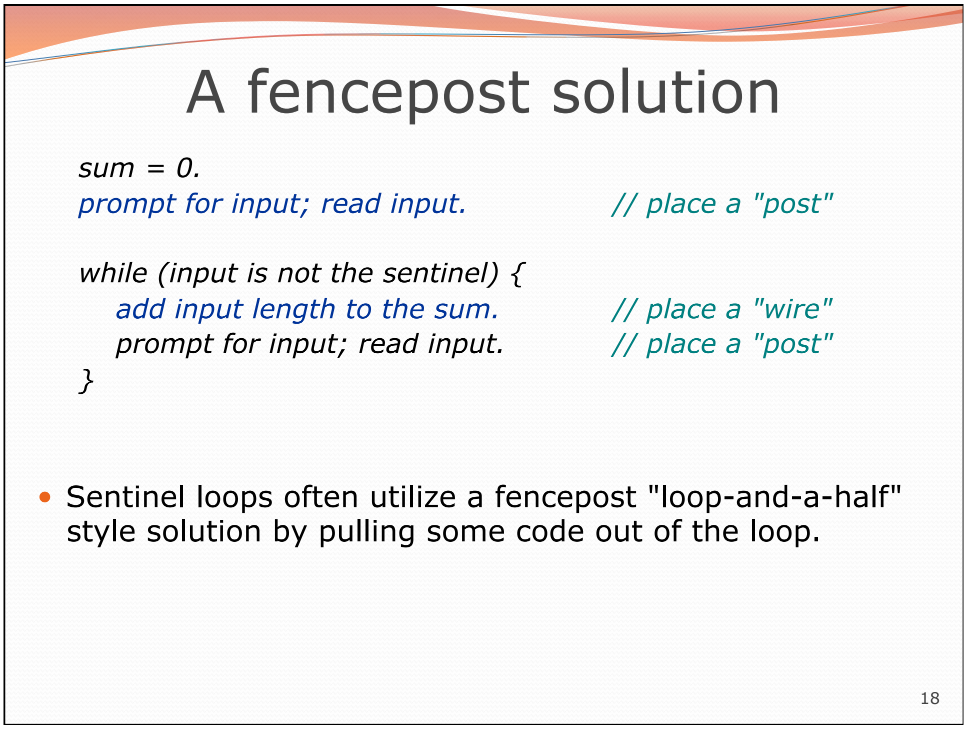
- Our code uses a pattern like this:

```
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.
```

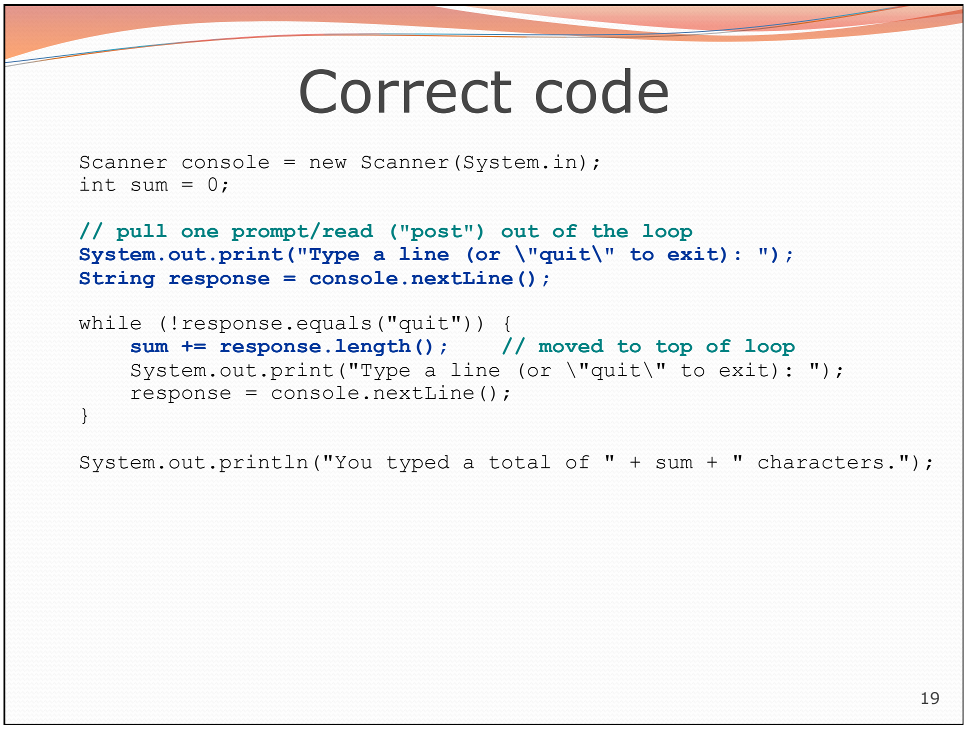
- This is a fencepost problem.
  - Must read *N* lines, but only sum the lengths of the first *N*-1.



A fencepost solution

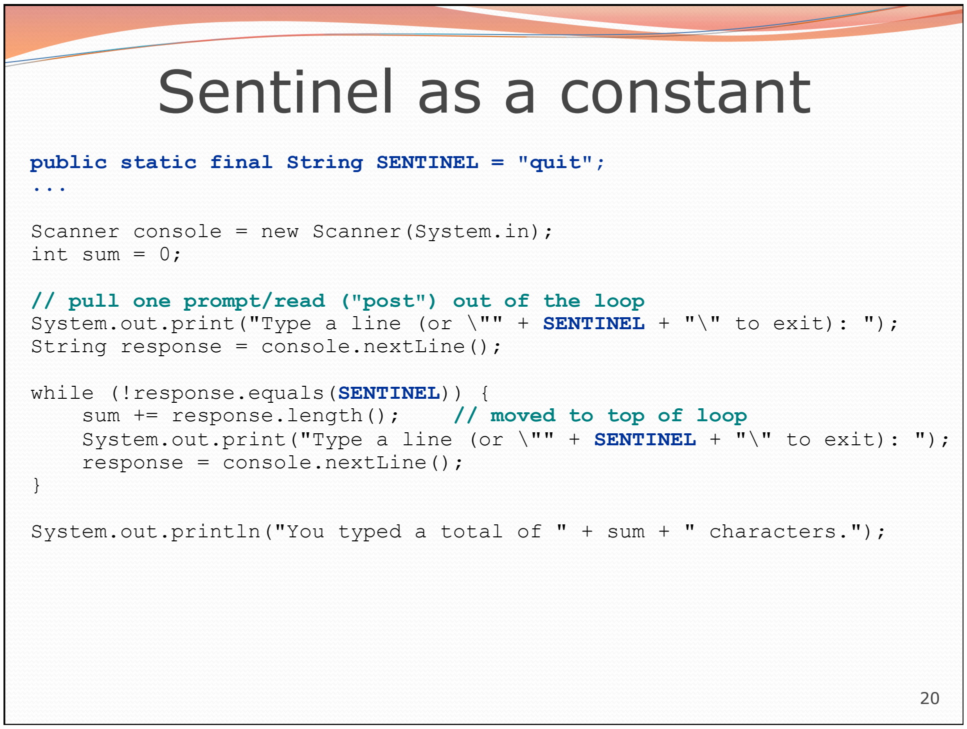
```
sum = 0.
prompt for input; read input.           // place a "post"

while (input is not the sentinel) {
    add input length to the sum.        // place a "wire"
    prompt for input; read input.       // 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

```
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.");
```