Building Java Programs
A Back to Basics Approach

CS 210

CHAPTER 5

PROGRAM LOGIC AND INDEFINITE LOOPS

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Topics will be covered

- Fencepost Algorithm
- `while` loops
- Random Numbers
- Type `boolean`
- Logical Assertions

Fencepost Algorithm

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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

- ```java
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,`


- ```java
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
}
```
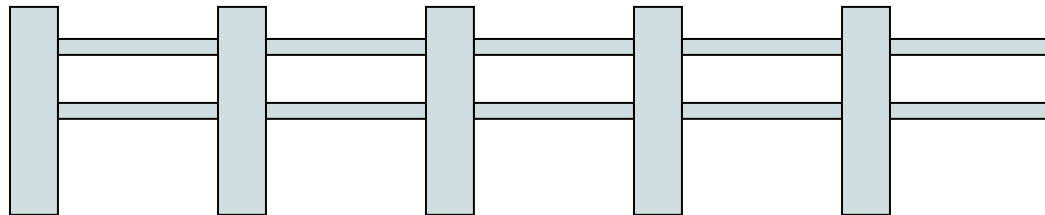
  ○ Output from `printNumbers(5)`: `, 1, 2, 3, 4, 5`

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.

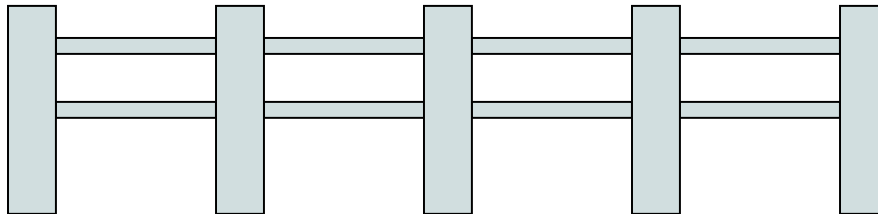> **place a post.**
> *for (length of fence - 1) {*
> > **place some wire.**
> > **place a post.**
> *}*

Fencepost method solution

```java
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:

```java
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
}
```

- 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

```java
// 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

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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 types "q" to quit.

The `while` loop

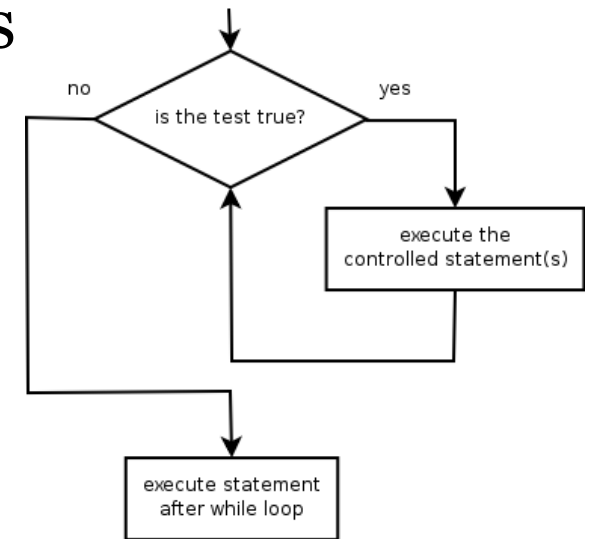- **`while` loop**: Repeatedly executes its body as long as a logical test is true.

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

- 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
```

- The `for` loop is just a specialized form of the `while` loop.

  ○ The following loops are equivalent:

  ```
  for (int num = 1; num <= 200; num = num * 2) {
        System.out.print(num + " ");
  }

  // actually, not a very compelling use of a while loop
  // (a for loop is better because the # of reps is
  definite)

  int num = 1;
  while (num <= 200) {
      System.out.print(num + " ");
      num = num * 2;
  }
  ```

Example `while` loop

```java
// 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.
```

- 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 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

```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.");
```

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Random numbers

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The Random class

- A `Random` object generates pseudo-random numbers.
  - Class `Random` is found in the `java.util` package.

    ```
    import java.util.*;
    ```

Method name	Description
`nextInt()`	returns a random integer
`nextInt(`**max**`)`	returns a random integer in the range [0, *max*) in other words, 0 to *max*-1 inclusive
`nextDouble()`	returns a random real number in the range [0.0, 1.0)

  - Example:

    ```
    Random rand = new Random();
    int randomNumber = rand.nextInt(10);   // 0-9
    ```

Generating random numbers

- Common usage: to get a random number from 1 to *N*

```
int n = rand.nextInt(20) + 1;   // 1-20
inclusive
```

- To get a number in arbitrary range [*min*, *max*] inclusive:

```
<name>.nextInt(<size of range>) + <min>
```

  - Where *<size of range>* is (*<max>* - *<min>* + 1)

  - Example: A random integer between 4 and 10 inclusive:

```
int n = rand.nextInt(7) + 4;
```

- Given the following declaration, how would you get:

```
Random rand = new Random();
```

  ○ A random number between 1 and 47 inclusive?
```
int random1 = rand.nextInt(47) + 1;
```

  ○ A random number between 23 and 30 inclusive?
```
int random2 = rand.nextInt(8) + 23;
```

  ○ A random even number between 4 and 12 inclusive?
```
int random3 = rand.nextInt(5) * 2 + 4;
```

- `nextDouble` **method returns a** `double` **between 0.0 - 1.0**

  - Example: Get a random GPA value between 1.5 and 4.0:
    ```
    double randomGpa = rand.nextDouble() * 2.5 + 1.5;
    ```

- Any set of possible values can be mapped to integers
  - code to randomly play Rock-Paper-Scissors:

    ```
    int r = rand.nextInt(3);
    if (r == 0) {
        System.out.println("Rock");
    } else if (r == 1) {
        System.out.println("Paper");
    } else {   // r == 2
        System.out.println("Scissors");
    }
    ```

- Write a program that simulates rolling of two 6-sided dice until their combined result comes up as 7.

```
2 + 4 = 6
3 + 5 = 8
5 + 6 = 11
1 + 1 = 2
4 + 3 = 7
You won after 5 tries!
```

Random answer

```java
// Rolls two dice until a sum of 7 is reached.
import java.util.*;

public class Dice {
    public static void main(String[] args) {
        Random rand = new Random();
        int tries = 0;

        int sum = 0;
        while (sum != 7) {
            // roll the dice once
            int roll1 = rand.nextInt(6) + 1;
            int roll2 = rand.nextInt(6) + 1;
            sum = roll1 + roll2;
            System.out.println(roll1 + " + " + roll2 + " = " + sum);
            tries++;
        }

        System.out.println("You won after " + tries + " tries!");
    }
}
```
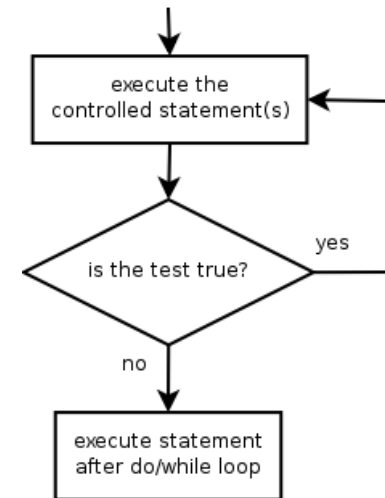
The `do/while` loop

- **`do/while` loop**: Performs its test at the *end* of each repetition.
  - Guarantees that the loop's `{}` body will run at least once.

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



```
// Example: prompt until correct password is typed
String phrase;
do {
    System.out.print("Type your password: ");
    phrase = console.next();
} while (!phrase.equals("abracadabra"));
```

do/while question

- Modify the previous `Dice` program to use `do/while`.

```
2 + 4 = 6
3 + 5 = 8
5 + 6 = 11
1 + 1 = 2
4 + 3 = 7
You won after 5 tries!
```

- Is `do/while` a good fit for our past `Sentinel` program?

do/while answer

```java
// Rolls two dice until a sum of 7 is reached.
import java.util.*;

public class Dice {
    public static void main(String[] args) {
        Random rand = new Random();
        int tries = 0;
        int sum;

        do {
            int roll1 = rand.nextInt(6) + 1;    // one roll
            int roll2 = rand.nextInt(6) + 1;
            sum = roll1 + roll2;
            System.out.println(roll1 + " + " + roll2 + " = " + sum);
            tries++;
        } while (sum != 7);

        System.out.println("You won after " + tries + " tries!");
    }
}
```

Type boolean

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Type `boolean`

- **`boolean`**: A logical type whose values are `true` and `false`.
  - A logical **<*test*>** is actually a `boolean` expression.
  - Like other types, it is legal to:
    - create a `boolean` variable
    - pass a `boolean` value as a parameter
    - return a `boolean` value from methods
    - call a method that returns a `boolean` and use it as a test

```java
boolean minor    = (age < 21);
boolean isProf   = name.contains("Prof");
boolean lovesCSE = true;

// allow only CSE-loving students over 21
if (minor || isProf || !lovesCSE) {
    System.out.println("Can't enter the club!");
}
```

Using boolean

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- # Why is type `boolean` **useful?**
  - Can capture a complex logical test result and use it later
  - Can write a method that does a complex test and returns it
  - Can pass around the result of a logical test (as param/return)
  - Makes code more readable

```
boolean goodAge    = age >= 12 && age < 29;
boolean goodHeight = height >= 78 && height < 84;
boolean rich       = salary >= 100000.0;

if ((goodAge && goodHeight) || rich) {
    System.out.println("Okay, let's go out!");
} else {
    System.out.println("It's not you, it's me...");
}
```

Methods that are tests

- **Methods can return** `boolean` **values.**
  - A call to such a method is used as a **test** in a loop or `if`.

```
Scanner console = new Scanner(System.in);
System.out.print("Type your first name: ");
String name = console.next();

if (name.startsWith("Dr.")) {
    System.out.println("Will you marry me?");
} else if (name.endsWith("Esq.")) {
    System.out.println("And I am Ted 'Theodore' Logan!");
}
```

String test methods

Method	Description
equals(**str**)	whether two strings contain the same characters
equalsIgnoreCase(**str**)	whether two strings contain the same characters, ignoring upper vs. lower case
startsWith(**str**)	whether one contains other's characters at start
endsWith(**str**)	whether one contains other's characters at end
contains(**str**)	whether the given string is found within this one

```
String name = console.next();

if (name.contains("Prof")) {

    System.out.println("When are your office hours?");

} else if (name.equalsIgnoreCase("MiDTerM")) {

    System.out.println("Study Hard, Study Smart!");
```

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Returning boolean

```java
public static boolean isPrime(int n) {
    int factors = 0;
    for (int i = 1; i <= n; i++) {
        if (n % i == 0) {
            factors++;
        }
    }

    if (factors == 2) {
        return true;
    } else {
        return false;
    }
}
```

- Calls to methods returning `boolean` can be used as tests:

```java
if (isPrime(57)) {
    ...
}
```

boolean return question

- Write a method `isVowel` that determines whether or not a `String` is a single vowel (a, e, i, o, u)

```
// naïve solution
public static boolean isVowel(String s) {
    if (s.equalsIgnoreCase("a")) {
        return true;
    } else if (s.equalsIgnoreCase("e")) {
        return true;
    } else if (s.equalsIgnoreCase("i")) {
        return true;
    } else if (s.equalsIgnoreCase("o")) {
        return true;
    } else if (s.equalsIgnoreCase("u")) {
        return true;
    } else {
        return false;
    }
}
```

boolean return question

- Write a method `isVowel` that determines whether or not a `String` is a single vowel (a, e, i, o, u)

```
// better solution
public static boolean isVowel(String s) {
    if (s.equalsIgnoreCase("a") ||  s.equalsIgnoreCase("e") ||
      s.equalsIgnoreCase("i") ||  s.equalsIgnoreCase("o") ||
      s.equalsIgnoreCase("u")) {
        return true;
    } else {
        return false;
    }
}
```

"Boolean Zen", part 1

- Students new to `boolean` often test if a result is `true`:

```
if (isPrime(57) == true) {      // bad

    ...

}
```

- But this is unnecessary and redundant. Preferred:

```
if (isPrime(57)) {                // good

    ...

}
```

- A similar pattern can be used for a false test:

```
if (isPrime(57) == false) {    // bad
if (!isPrime(57)) {              // good
```

"Boolean Zen", part 2

- **Methods that return `boolean` often have an `if/else` that returns `true` or `false`:**

```java
public static boolean bothOdd(int n1, int n2) {
    if (n1 % 2 != 0 && n2 % 2 != 0) {
        return true;
    } else {
        return false;
    }
}
```

  - But the code above is unnecessarily verbose.

Solution w/ `boolean` variable

- We could store the result of the logical test.

```
public static boolean bothOdd(int n1, int n2) {
    boolean test = (n1 % 2 != 0 && n2 % 2 != 0);
    if (test) {      // test == true
        return true;
    } else {         // test == false
        return false;
    }
}
```

- Notice: Whatever `test` is, we want to return that.
  - If `test` is `true` , we want to return `true`.
  - If `test` is `false`, we want to return `false`.

Solution w/ "Boolean Zen"

- **Observation: The `if/else` is unnecessary.**
  - The variable `test` stores a `boolean` value;
    its value is exactly what you want to return. So return that!

```java
public static boolean bothOdd(int n1, int n2) {
    boolean test = (n1 % 2 != 0 && n2 % 2 != 0);
    return test;
}
```

- **An even shorter version:**
  - We don't even need the variable `test`.
    We can just perform the test and return its result in one step.

```java
public static boolean bothOdd(int n1, int n2) {
    return (n1 % 2 != 0 && n2 % 2 != 0);
}
```

"Boolean Zen" template

- Replace

```
public static boolean name(parameters) {
    if (test) {
        return true;
    } else {
        return false;
    }
}
```

- with

```
public static boolean name(parameters) {
    return test;
}
```

Improved `isPrime` method

- The following version utilizes Boolean Zen:

```java
public static boolean isPrime(int n) {
    int factors = 0;
    for (int i = 1; i <= n; i++) {
        if (n % i == 0) {
            factors++;
        }
    }
    return factors == 2;    // if n has 2 factors -> true
}
```

boolean Zen question

- Rewrite `isVowel` to use Boolean Zen.

```java
// Enlightened version.  I have seen the true way (and false way)
public static boolean isVowel(String s) {
    return s.equalsIgnoreCase("a") || s.equalsIgnoreCase("e") ||
           s.equalsIgnoreCase("i") || s.equalsIgnoreCase("o") ||
           s.equalsIgnoreCase("u");
}
```

De Morgan's Law

- **De Morgan's Law**: Rules used to negate boolean tests.

  - Useful when you want the opposite of an existing test.

Original Expression	Negated Expression	Alternative
a && b	!a || !b	!(a && b)
a || b	!a && !b	!(a || b)

  - Example:

Original Code	Negated Code

if (x == 7 && y > 3) {
    ...
}
	if (x != 7 || y <= 3) {
	    ...
	}

Boolean practice questions

- Write a method `isNonVowel` that returns whether a `String` is any character except a vowel.
  - `isNonVowel("q")` returns `true`
  - `isNonVowel("A")` returns `false`
  - `isNonVowel("e")` returns `false`

Boolean practice answers

```java
// Enlightened "Boolean Zen" version
public static boolean isNonVowel(String s) {
    return !s.equalsIgnoreCase("a") && !s.equalsIgnoreCase("e") &&
            !s.equalsIgnoreCase("i") && !s.equalsIgnoreCase("o") &&
            !s.equalsIgnoreCase("u");

    // or, return !isVowel(s);
}
```

"Short-circuit" evaluation

- Java stops evaluating a test if it knows the answer.
  - `&&` stops early if any part of the test is `false`
  - `||` stops early if any part of the test is `true`

- The following test will crash if s2's length is less than 2:

```java
// Returns true if s1 and s2 end with the same two letters.
public static boolean rhyme(String s1, String s2) {
    return s1.endsWith(s2.substring(s2.length() - 2)) &&
        s1.length() >= 2 && s2.length() >= 2;
}
```

- The following test will not crash; it stops if length < 2:

```java
// Returns true if s1 and s2 end with the same two letters.
public static boolean rhyme(String s1, String s2) {
    return s1.length() >= 2 && s2.length() >= 2 &&
        s1.endsWith(s2.substring(s2.length() - 2));
}
```

When to return?

- Methods with loops and return values can be tricky.
  - When and where should the method return its result?

- Write a method `seven` that accepts a `Random` parameter and uses it to draw up to ten lotto numbers from 1-30.

  - If any of the numbers is a lucky 7, the method should stop and return `true`. If none of the ten are 7 it should return `false`.

  - The method should print each number as it is drawn.

    ```
    15 29 18 29 11 3 30 17 19 22    (first call)
    29 5 29 4 7 (second call)
    ```

Flawed solution

```java
// Draws 10 lotto numbers; returns true if one is 7.
public static boolean seven(Random rand) {
    for (int i = 1; i <= 10; i++) {
        int num = rand.nextInt(30) + 1;
        System.out.print(num + " ");

        if (num == 7) {
            return true;
        } else {
            return false;
        }
    }
}
```

- The method always returns immediately after the first roll.
- This is wrong if that roll isn't a 7; we need to keep rolling.

Returning at the right time

```
// Draws 10 lotto numbers; returns true if one is 7.
public static boolean seven(Random rand) {
    for (int i = 1; i <= 10; i++) {
        int num = rand.nextInt(30) + 1;
        System.out.print(num + " ");

        if (num == 7) {      // found lucky 7; can exit now
            return true;
        }
    }

    return false;    // if we get here, there was no 7
}
```

- Returns `true` immediately if 7 is found.
- If 7 isn't found, the loop continues drawing lotto numbers.
- If all ten aren't 7, the loop ends and we return `false`.

Boolean return questions

- `hasAnOddDigit` : returns `true` if <u>any</u> digit of an integer is odd.

  - `hasAnOddDigit(4822116)` returns `true`
  - `hasAnOddDigit(2448)` returns `false`

- `allDigitsOdd` : returns `true` if <u>every</u> digit of an integer is odd.

  - `allDigitsOdd(135319)` returns `true`
  - `allDigitsOdd(9174529)` returns `false`

- `isAllVowels` : returns `true` if <u>every</u> char in a `String` is a vowel.

  - `isAllVowels("eIeIo")` returns `true`
  - `isAllVowels("oink")` returns `false`

Boolean return answers

```java
public static boolean hasAnOddDigit(int n) {
    while (n != 0) {
        if (n % 2 != 0) {    // check whether last digit is odd
            return true;
        }
        n = n / 10;
    }
    return false;
}
public static boolean allDigitsOdd(int n) {
    while (n != 0) {
        if (n % 2 == 0) {    // check whether last digit is even
            return false;
        }
        n = n / 10;
    }
    return true;
}
public static boolean isAllVowels(String s) {
    for (int i = 0; i < s.length(); i++) {
        String letter = s.substring(i, i + 1);
        if (!isVowel(letter)) {
            return false;
        }
    }
    return true;
}
```

Logical Assertions

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Logical assertions

- **assertion**: A statement that is either true or false.

  Examples:
  - Java was created in 1995.
  - The sky is purple.
  - 23 is a prime number.
  - 10 is greater than 20.
  - x divided by 2 equals 7. *(depends on the value of x)*

- An assertion might be false ("The sky is purple" above), but it is still an assertion because it is a true/false statement.

- Suppose you have the following code:

```
if (x > 3) {
    // Point A
    x--;
} else {
    // Point B
    x++;
    // Point C
}
// Point D
```

- What do you know about x's value at the three points?
  - Is x > 3? Always? Sometimes? Never?

Assertions in code

- We can make assertions about our code and ask whether they are true at various points in the code.
  - Valid answers are ALWAYS, NEVER, or SOMETIMES.

```
System.out.print("Type a nonnegative number: ");
double number = consdle.nextDouble();
// Point A: is number < 0.0 here?                    (SOMETIMES)

while (number < 0.0) {
    // Point B: is number < 0.0 here?                (ALWAYS)
    System.out.print("Negative; try again: ");

    number = console.nextDouble();
    // Point C: is number < 0.0 here?                (SOMETIMES)
}

// Point D: is number < 0.0 here?                    (NEVER)
```

Reasoning about assertions

- Right after a variable is initialized, its value is known:
  ```
  int x = 3;
  // is x > 0?  ALWAYS
  ```

- In general you know nothing about parameters' values:
  ```
  public static void mystery(int a, int b) {
  // is a == 10?  SOMETIMES
  ```

- But inside an `if`, `while`, etc., you may know something:
  ```
  public static void mystery(int a, int b) {
      if (a < 0) {
          // is a == 10?  NEVER
          ...
      }
  }
  ```

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Assertions and loops

- At the start of a loop's body, the loop's test must be `true`:
```
while (y < 10) {
    // is y < 10?  ALWAYS
    ...
}
```

- After a loop, the loop's test must be false:
```
while (y < 10) {
    ...
}
// is y < 10?  NEVER
```

- Inside a loop's body, the loop's test may become false:
```
while (y < 10) {
    y++;
    // is y < 10?  SOMETIMES
}
```

"Sometimes"

- Things that cause a variable's value to be unknown (often leads to "sometimes" answers):

  - reading from a `Scanner`
  - reading a number from a `Random` object
  - a parameter's initial value to a method

- If you can reach a part of the program both with the answer being "yes" and the answer being "no", then the correct answer is "sometimes".

  - If you're unsure, "Sometimes" is a good guess.

```
public static void mystery(int x, int y) {
    int z = 0;

    // Point A

    while (x >= y) {
        // Point B
        x = x - y;
        z++;

        if (x != y) {
            // Point C
            z = z * 2;
        }

        // Point D

    }

    // Point E
    System.out.println(z);
}
```

Which of the following assertions are true at which point(s) in the code? Choose ALWAYS, NEVER, or SOMETIMES.

	x < y	x == y	z == 0
Point A	SOMETIMES	SOMETIMES	ALWAYS
Point B	NEVER	SOMETIMES	SOMETIMES
Point C	SOMETIMES	NEVER	NEVER
Point D	SOMETIMES	SOMETIMES	NEVER
Point E	ALWAYS	NEVER	SOMETIMES

Assertion Exercise 1

```
public static int mystery(Scanner console) {
    int prev = 0;
    int count = 0;
    int next = console.nextInt();

    // Point A

    while (next != 0) {
        // Point B

        if (next == prev) {
            // Point C

            count++;
        }

        prev = next;
        next = console.nextInt();

        // Point D

    }

    // Point E

    return count;
}
```

#1-#15: Which of the following assertions are true at which point(s) in the code? Choose **A** (ALWAYS), **N** (NEVER), or **S** (SOMETIMES).

	next == 0	prev == 0	next == prev
Point A	#1	#2	#3
Point B	#4	#5	#6
Point C	#7	#8	#9
Point D	#10	#11	#12
Point E	#13	#14	#15

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Assertion Exercise 2

```
// Assumes y >= 0, and returns x^y
public static int pow(int x, int y) {
    int prod = 1;

    // Point A
    while (y > 0) {
        // Point B
        if (y % 2 == 0) {
            // Point C
            x = x * x;
            y = y / 2;
            // Point D
        } else {
            // Point E
            prod = prod * x;
            y--;
            // Point F
        }
    }
    // Point G
    return prod;
}
```

#16-#29: Which of the following assertions are true at which point(s) in the code? Choose **A** (ALWAYS), **N** (NEVER), or **S** (SOMETIMES).

	`y > 0`	`y % 2 == 0`
Point A	#16	#17
Point B	#18	#19
Point C	#20	#21
Point D	#22	#23
Point E	#24	#25
Point F	#26	#27
Point G	#28	#29

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The End 🏝️

CS 210

CHAPTER 5

PROGRAM LOGIC AND INDEFINITE LOOPS

Winnie Li

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- Write a program that plays an adding game.
  - Ask user to solve random adding problems with 2-5 numbers.
  - The user gets 1 point for a correct answer, 0 for incorrect.
  - The program stops after 3 incorrect answers.

```
4 + 10 + 3 + 10 = 27
9 + 2 = 11
8 + 6 + 7 + 9 = 25
Wrong! The answer was 30
5 + 9 = 13
Wrong! The answer was 14
4 + 9 + 9 = 22
3 + 1 + 7 + 2 = 13
4 + 2 + 10 + 9 + 7 = 42
Wrong! The answer was 32
You earned 4 total points.
```

Random answer

```java
// Asks the user to do adding problems and scores them.
import java.util.*;

public class AddingGame {
    public static void main(String[] args) {
        Scanner console = new Scanner(System.in);
        Random rand = new Random();

        // play until user gets 3 wrong
        int points = 0;
        int wrong = 0;
        while (wrong < 3) {
            int result = play(console, rand);   // play one game
            if (result > 0) {
                points++;
            } else {
                wrong++;
            }
        }

        System.out.println("You earned " + points + " total
    points.");
    }
```

- Improve our "rhyme" / "alliterate" program to use boolean methods to test for rhyming and alliteration.

```
Type two words: Bare blare
They rhyme!
They alliterate!
```

Boolean answer

```java
    if (rhyme(word1, word2)) {
        System.out.println("They rhyme!");
    }
    if (alliterate(word1, word2)) {
        System.out.println("They alliterate!");
    }
    ...

// Returns true if s1 and s2 end with the same two letters.
public static boolean rhyme(String s1, String s2) {
    if (s2.length() >= 2 && s1.endsWith(s2.substring(s2.length() - 2))) {
        return true;
    } else {
        return false;
    }
}

// Returns true if s1 and s2 start with the same letter.
public static boolean alliterate(String s1, String s2) {
    if (s1.startsWith(s2.substring(0, 1))) {
        return true;
    } else {
        return false;
    }
}
```

Boolean Zen answer

```java
public static void main(String[] args) {
    Scanner console = new Scanner(System.in);
    System.out.print("Type two words: ");
    String word1 = console.next().toLowerCase();
    String word2 = console.next().toLowerCase();

    if (rhyme(word1, word2)) {
        System.out.println("They rhyme!");
    }
    if (alliterate(word1, word2)) {
        System.out.println("They alliterate!");
    }
}

// Returns true if s1 and s2 end with the same two letters.
public static boolean rhyme(String s1, String s2) {
    return s2.length() >= 2 && s1.endsWith(s2.substring(s2.length() - 2));
}

// Returns true if s1 and s2 start with the same letter.
public static boolean alliterate(String s1, String s2) {
    return s1.startsWith(s2.substring(0, 1));
}
```

- Write a method `digitSum` that accepts an integer parameter and returns the sum of its digits.

  ○ Assume that the number is non-negative.

  ○ Example: `digitSum(29107)` returns 2+9+1+0+7 or 19

  ○ Hint: Use the `%` operator to extract a digit from a number.

while loop answer

```
public static int digitSum(int n) {
    n = Math.abs(n);           // handle negatives

    int sum = 0;
    while (n > 0) {
        sum = sum + (n % 10);  // add last digit
        n = n / 10;            // remove last digit
    }

    return sum;
}
```