Unit 4: Iteration

For Loops

Adapted from:

1) Building Java Programs: A Back to Basics Approach by Stuart Reges and Marty Stepp

2) Runestone CSAwesome Curriculum

https://longbaonguyen.github.io

Categories of loops

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** is usually used for indefinite loops.

Categories of loops

definite loop: Executes a known number of times.

- Print "hello" 10 times.
- Find all the prime numbers up to an integer *n*.
- Print each odd number between 5 and 127.

In this lecture, we will see that a for loop is often used to implement a definite loop.

for loop syntax

```
for (initialization; test; update) {
    statement;
    statement;
    ...
    statement;
}
```

header

body

- Perform **initialization** once.
- Repeat the following:
  - Check if the **test** is true. If not, stop.
  - Execute the **statements**.
  - Perform the **update**.

Examples

```
for(int i = 1; i <= 5; i++){
    System.out.print("Hi");
}
```

Output:

```
HiHiHiHiHi
```

```
for(int i = 1; i <= 5; i++){
    System.out.print(i);
}
```

Output:

```
12345
```

For vs While Syntax

Compare the different syntax between the while and for loops.

```
for(int i = 1; i <= 5; i++){
    System.out.print("Hi");
}
```

A for loop's syntax is more compact. The three steps: initialization, test and update are all done on the same line.

```
int i = 1;
while(i <= 5){
      System.out.print("Hi");
      i++;
}
```

The while loops accomplish these steps in three different places.

Initialization

```
for (int i = 1; i <= 6; i++) {
    System.out.println("Hi");
}
```

- Tells Java what variable to use in the loop
  - Performed once as the loop begins
  - The variable is called a *loop counter*
    - can use any name, not just `i`
    - can start at any value, not just `1`

Test

```
for (int i = 1; i <= 6; i++) {
    System.out.println("Hi");
}
```

- Tests the loop counter variable against a limit
  - Uses comparison operators:

<	less than
<=	less than or equal to
>	greater than
>=	greater than or equal to

Update

```
for (int i = 1; i <= 6; i++) {
    System.out.println("Hi");
}
```

- Update the loop variable

Repetition over a range

Use a for loop to print:

```
System.out.println("1 squared = " + 1 * 1);
System.out.println("2 squared = " + 2 * 2);
System.out.println("3 squared = " + 3 * 3);
System.out.println("4 squared = " + 4 * 4);
System.out.println("5 squared = " + 5 * 5);
System.out.println("6 squared = " + 6 * 6);
```

– Intuition: "I want to print a line for each number from 1 to 6"

Answer

```
for (int i = 1; i <= 6; i++) {
    System.out.println(i + " squared = " + i * i);
}
```

Output:

```
1 squared = 1
2 squared = 4
3 squared = 9
4 squared = 16
5 squared = 25
6 squared = 36
```

Example

Write a for loop to print numbers that are multiples of 4 up to and including 40.

Method 1:

```
for (int i = 4; i <= 40; i += 4)
          System.out.print(i + " ");
```

Method 2(works more generally):

```
for (int i = 4; i <= 40; i += 1){
       if(i % 4 == 0)
          System.out.print(i + " ");
}
```

Counting down

- The **update** can use `--` to make the loop count down.
  - The **test** must say > instead of <

```
System.out.print("T-minus ");
for (int i = 10; i >= 1; i--) {
     System.out.print(i + ", ");
}
System.out.println("blastoff!");
System.out.println("The end.");
```

  - Output:

```
T-minus 10, 9, 8, 7, 6, 5, 4, 3, 2, 1, blastoff!
The end.
```

isPrime

```
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:

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

isPrime method

The condition below is verbose. Can we simplify it? Replace it with one statement!

```
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;

}
```

Improved isPrime method

The following version utilizes Boolean Zen:

```
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
}
```

For vs While

Write a loop to compute the sum:

1 + 2 + 3 + … + 99 + 100

```
int sum = 0;
int number = 1;
while(number <= 100){
    sum += number;
    number++;
}
```

Both for and while loops can be used to solve this problem.

A for loop's syntax is more compact.

```
int sum = 0;
for(int i = 1; i <= 100; i++){
    sum += i;
}
```

For vs. While

Although for and while loop can generally be interchangeable. It is best practice to use a for loop as a definite loop where the beginning and termination of the loop is well defined.

```
for(int i = 1; i <= 100; i++){
     System.out.println(i);
}
```

This for loop executes 100 times. It is a definite loop. It is usually better to use a for loop as a definite loop.

For vs. While

If the termination condition of a loop is less well defined, use a while loop. For example, suppose you require a positive integer input from the user. The following will loop until a positive number is entered.

```
Scanner inp = new Scanner(System.in);
System.out.print("Enter a positive number:");
int x = inp.nextInt();

while(x <= 0){
      System.out.print("Enter a positive number:");
      x = inp.nextInt();
}
System.out.print("Thank you!");
```

Sample Output:

```
Enter a positive number: -4
Enter a positive number: -5
Enter a positive number: -10
Enter a positive number: 6
Thank you!
```

This while loop executes an unknown number of times since you don't know when the user will enter a positive number. It is an indefinite loop. It is better to use a while loop here.

For vs. While

The previous code can be done more simply:

```
Scanner inp = new Scanner(System.in);
int x = 0;
while(x <= 0){
     System.out.print("Enter a positive number:");
     x = inp.nextInt();
}
System.out.print("Thank you!");
```

String Algorithms: For Loops

Loops allow us to do String traversals. Suppose we want to know the number of spaces in a String.

```
public static int countSpaces(String str){
      int count = 0;
      for(int i = 0; i < str.length(); i++){
            if(str.substring(i, i + 1).equals(" "))
                  count++;
      }
      return count;
}
```

String Algorithms: For Loops

Assume that a given String is a sequence of words separated by spaces, return the number of words. Use countSpaces.

```
public static int numOfWords(String str){
      return countSpaces(str) + 1;
}
```

Remove Spaces (For)

Given a string, return the string with all of its spaces removed.

We now implement this with a **for loop**. Start with an empty string. Then examine every letter and if it is NOT a space, add it to the string. This builds up the String one letter at a time but avoids the spaces. For some students, this may be easier to understand and write then the previous while loop version.

```
public static String removeSpaces1(String str){
      String ans = "";
      for(int i = 0; i < str.length(); i++){
            String letter = str.substring(i, i+1);
            if(!letter.equals(" "))
                  ans += letter;
      }
      return ans;
}
```

Remove Spaces (While)

Given a string, return the string with all of its spaces removed.

We will do this first with a **while loop**.
One way to do this is to use a while loop with indexOf.

```java
public static String removeSpaces2(String str){
      while(str.indexOf(" ") != -1){
         int indexSpace = str.indexOf(" ");
         String first = str.substring(0, indexSpace);
         String second = str.substring(indexSpace + 1);
         str = first + second; // first space removed
      }
      return str;
}
```

Palindrome

Given a string, return whether the string is a palindrome(reads the same forward as backwards).

```
public static boolean isPalindrome(String str){
        int len = str.length();
        for(int i = 0; i < len; i++){
                String current = str.substring(i, i + 1);
                String opposite = str.substring(len – 1 - i, len - i);
                if(!current.equals(opposite))
                        return false;
        }
        return true;
}
```

Can we make the code slightly more efficient?

Improved Palindrome

We can go just to the middle of the String.

```
public static boolean isPalindrome(String str){
        int len = str.length();
        for(int i = 0; i < len/2; i++){
                String current = str.substring(i, i + 1);
                String opposite = str.substring(len – 1 - i, len - i);
                if(!current.equals(opposite))
                        return false;
        }
        return true;
}
```

For Loop in Movies

Groundhog Day(1993); Bill Murray.

Looper(2010); Bruce Willis and Joseph Gordon-Levitt, Emily Blunt.

Edge of Tomorrow(2014); Tom Cruise, Emily Blunt.

Happy Death Day(2017).

TV-Shows:

Russian Doll(Netflix, Emmy-nominated)

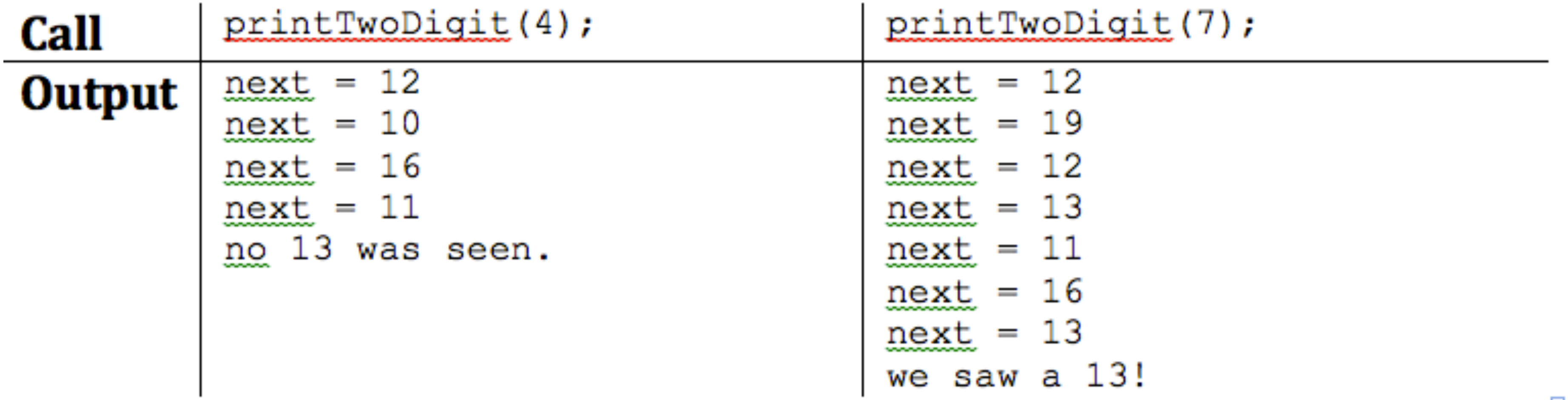
Lab 1

Write a static method named `printTwoDigit` that accepts an integer *n* as a parameter and that prints a series of *n* randomly generated numbers. The method should use Math.random() to select numbers in the range of 10 to 19 inclusive where each number is equally likely to be chosen.

After displaying each number that was produced, the method should indicate whether the number 13 was ever selected ("we saw a 13!") or not ("no 13 was seen."). You may assume that the value of *n* passed is at least 0. **Use a boolean to keep track of whether 13 was seen.**

You should an output similar to below. (see next slide)

Lab 1



Call	printTwoDigit(4);	printTwoDigit(7);

Output	next = 12
	next = 10
	next = 16
	next = 11
	no 13 was seen.
		next = 12
		next = 19
		next = 12
		next = 13
		next = 11
		next = 16
		next = 13
		we saw a 13!

References

1) Building Java Programs: A Back to Basics Approach by Stuart Reges and Marty Stepp

2) Runestone CSAwesome Curriculum: https://runestone.academy/runestone/books/published/csawesome/index.html

For more tutorials/lecture notes in Java, Python, game programming, artificial intelligence with neural networks:

https://longbaonguyen.github.io