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.
Repetition with for loops

• So far, repeating a statement is redundant:

```java
System.out.println("Homer says:");
System.out.println("I am so smart");
System.out.println("I am so smart");
System.out.println("I am so smart");
System.out.println("I am so smart");
System.out.println("S-M-R-T... I mean S-M-A-R-T");
```

• Java's for loop statement performs a task many times.

```java
System.out.println("Homer says:");
for (int i = 1; i <= 4; i++) { // repeat 4 times
    System.out.println("I am so smart");
}
System.out.println("S-M-R-T... I mean S-M-A-R-T");
```
for loop syntax

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

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

```java
for (int i = 1; i <= 6; i++) {
    System.out.println("I am so smart");
}
```

- 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`
for (int i = 1; i <= 6; i++) {
    System.out.println("I am so smart");
}

• 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
Repetition over a range

Use a for loop to print:

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

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

Whoo!
Write a for loop to print: 5 9 13 17 21 25

Answer:

```java
for (int i = 5; i <= 25; i += 4) {
    System.out.print(i + " ");
}
```
Counting down

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

```java
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.
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.

TV-Shows:
Russian Doll (Netflix, Emmy-nominated)
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)) {
    ...
}
The condition below is verbose. Can we simplify it? Replace it with one statement!

```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;
}
```
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
}
```
Write a loop to compute the sum:

\[ 1 + 2 + 3 + \ldots + 99 + 100 \]

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

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

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

```java
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.
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.

```java
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 a indefinite loop. It is better to use a while loop here.
Loops allow us to do String traversals. Suppose we want to know the number of spaces in a String.

```java
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.

```java
public static int numOfWords(String str) {
    return countSpaces(str) + 1;
}
```
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 removeSpaces1(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;
}
```
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.

```java
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;
}
```
Palindrome

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

```java
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?
We can go just to the middle of the String.

```java
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;
}
```
Lab 1

On replit classroom, please do For Loops: 19 – 33 (some of the numbers are skipped, total of 11 problems)
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.

You should an output similar to below. (see next slide)
<table>
<thead>
<tr>
<th>Call</th>
<th>printTwoDigit(4);</th>
</tr>
</thead>
<tbody>
<tr>
<td>next</td>
<td>12</td>
</tr>
<tr>
<td>next</td>
<td>10</td>
</tr>
<tr>
<td>next</td>
<td>16</td>
</tr>
<tr>
<td>next</td>
<td>11</td>
</tr>
<tr>
<td>no 13 was seen.</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Call</th>
<th>printTwoDigit(7);</th>
</tr>
</thead>
<tbody>
<tr>
<td>next</td>
<td>12</td>
</tr>
<tr>
<td>next</td>
<td>19</td>
</tr>
<tr>
<td>next</td>
<td>12</td>
</tr>
<tr>
<td>next</td>
<td>13</td>
</tr>
<tr>
<td>next</td>
<td>11</td>
</tr>
<tr>
<td>next</td>
<td>16</td>
</tr>
<tr>
<td>next</td>
<td>13</td>
</tr>
<tr>
<td>we saw a 13!</td>
<td></td>
</tr>
</tbody>
</table>
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