Nested for loops

Subset of the Supplement Lesson slides from: Building Java Programs, Chapter 2 by Stuart Reges and Marty Stepp (http://www.buildingjavaprograms.com/ )
Nested loops

• **nested loop**: A loop placed inside another loop.

```java
for (int i = 1; i <= 5; i++) {
    for (int j = 1; j <= 10; j++) {
        System.out.print("*");
    }
    System.out.println();  // to end the line
}
```

• Output:

```
**********
**********
**********
**********
**********
```

• The outer loop repeats 5 times; the inner one 10 times.
  – "sets and reps" exercise analogy
Nested for loop exercise

- What is the output of the following nested for loops?

```java
for (int i = 1; i <= 5; i++) {
    for (int j = 1; j <= i; j++) {
        System.out.print("*");
    }
    System.out.println();
}
```

- Output:

```
*  
** 
*** 
**** 
***** 
```
Nested for loop exercise

• What is the output of the following nested for loops?

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

• Output:

```
1
22
333
4444
55555
```
Both of the following sets of code produce *infinite loops*:

```java
for (int i = 1; i <= 5; i++) {
    for (int j = 1; j <= 10; i++) {
        System.out.print("*");
    }
    System.out.println();
}
```

```java
for (int i = 1; i <= 5; i++) {
    for (int j = 1; j <= 10; i++) {
        System.out.print("*");
    }
    System.out.println();
}
```
• What nested for loops produce the following output?

\begin{itemize}
  \item \textit{inner loop (repeated characters on each line)}
  \begin{itemize}
    \item \ldots 1
    \item \ldots 2
    \item \ldots 3
    \item 4
    \item 5
  \end{itemize}
  \item \textit{outer loop (loops 5 times because there are 5 lines)}
\end{itemize}

• We must build multiple complex lines of output using:
  \begin{itemize}
    \item an \textit{outer "vertical" loop} for each of the lines
    \item \textit{inner "horizontal" loop(s)} for the patterns within each line
  \end{itemize}
Outer and inner loop

• First write the outer loop, from 1 to the number of lines.

```java
for (int line = 1; line <= 5; line++) {
    ...
}
```

• Now look at the line contents. Each line has a pattern:
  – some dots (0 dots on the last line), then a number

```
...1
...2
..3
.4
5
```

  – Observation: the number of dots is related to the line number.
for (int count = 1; count <= 5; count++) {
    System.out.print( ... );
}

– What statement in the body would cause the loop to print:
  4 7 10 13 16

for (int count = 1; count <= 5; count++) {
    System.out.print(3 * count + 1 + " ");
}
Loop tables

• What statement in the body would cause the loop to print:
  2 7 12 17 22

• To see patterns, make a table of count and the numbers.
  – Each time count goes up by 1, the number should go up by 5.
  – But \( \text{count} \times 5 \) is too great by 3, so we subtract 3.

<table>
<thead>
<tr>
<th>count</th>
<th>number to print</th>
<th>(5 \times \text{count})</th>
<th>(5 \times \text{count} - 3)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2</td>
<td>5</td>
<td>2</td>
</tr>
<tr>
<td>2</td>
<td>7</td>
<td>10</td>
<td>7</td>
</tr>
<tr>
<td>3</td>
<td>12</td>
<td>15</td>
<td>12</td>
</tr>
<tr>
<td>4</td>
<td>17</td>
<td>20</td>
<td>17</td>
</tr>
<tr>
<td>5</td>
<td>22</td>
<td>25</td>
<td>22</td>
</tr>
</tbody>
</table>
• What statement in the body would cause the loop to print:
  17 13 9 5 1

• Let's create the loop table together.
  – Each time count goes up 1, the number printed should ...
  – But this multiple is off by a margin of ...

<table>
<thead>
<tr>
<th>count</th>
<th>number to print</th>
<th>-4 * count</th>
<th>-4 * count + 21</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>17</td>
<td>-4</td>
<td>17</td>
</tr>
<tr>
<td>2</td>
<td>13</td>
<td>-8</td>
<td>13</td>
</tr>
<tr>
<td>3</td>
<td>9</td>
<td>-12</td>
<td>9</td>
</tr>
<tr>
<td>4</td>
<td>5</td>
<td>-16</td>
<td>5</td>
</tr>
<tr>
<td>5</td>
<td>1</td>
<td>-20</td>
<td>1</td>
</tr>
</tbody>
</table>
Nested for loop exercise

- Make a table to represent any patterns on each line.

- To print a character multiple times, use a `for` loop.

```java
for (int j = 1; j <= 4; j++) {
    System.out.print("."); // 4 dots
}
```
Nested for loop solution

• Answer:
  ```java
  for (int line = 1; line <= 5; line++) {
    for (int j = 1; j <= (-1 * line + 5); j++) {
      System.out.print(".");
    }
    System.out.println(line);
  }
  ```

• Output:
  ```
  ....1
  ...2
  ..3
  .4
  5
  ```
Nested for loop exercise

• What is the output of the following nested for loops?

```java
for (int line = 1; line <= 5; line++) {
    for (int j = 1; j <= (-1 * line + 5); j++) {
        System.out.print("");
    }
    for (int k = 1; k <= line; k++) {
        System.out.print(line);
    }
    System.out.println();
}
```

• Answer:

```
....1
...22
..333
.4444
55555
```
Nested for loop exercise

• Modify the previous code to produce this output:

....1
...2.
..3..
.4...
5....

• Answer:

```java
for (int line = 1; line <= 5; line++) {
    for (int j = 1; j <= (-1 * line + 5); j++) {
        System.out.print(".");
    }
    System.out.println(line);
    for (int j = 1; j <= (line - 1); j++) {
        System.out.print(".");
    }
    System.out.println();
}
```