CIS 110: Introduction to Computer Programming

Lecture 5

The Loop-the-Loop

(§ 2.3-2.4)

Outline

1. For-loops!
2. Algorithm Design and Pseudocode

Announcements

- Date of the final is tentatively:

  MONDAY, DECEMBER 19th, 6-8 PM

  – If you have a conflict, please let me know ASAP.
- Need more practice? Try Practice-it!
  – Web-based tool where you can work on practice problems that are automatically checked online.
  – Linked off of the course webpage.

For Loops

Redundancy in Patterns

- Problem: write a program that prints out successive cubes.

Output:

```
0^3 = 0
1^3 = 1
2^3 = 8
3^3 = 27
4^3 = 64
```


A Solution with Our Current Tools

```
public class Cubes {
  public static void main(String[] args) {
    System.out.println("0^3 = " + 0 * 0 * 0);
    System.out.println("1^3 = " + 1 * 1 * 1);
    System.out.println("2^3 = " + 2 * 2 * 2);
    System.out.println("3^3 = " + 3 * 3 * 3);
    System.out.println("4^3 = " + 4 * 4 * 4);
  }
}
```

- Pretty obvious repetition, but we have no way of dealing with it…

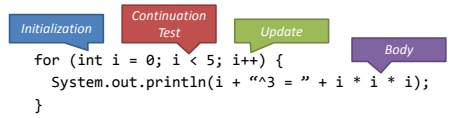
Our First For-loop

```
public class Cubes {
  public static void main(String[] args) {
    for (int i = 0; i < 5; i++) {
      System.out.println(i + "^3 = " + i * i * i);
    }
  }
}
```

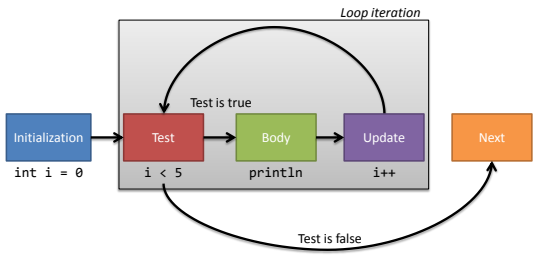
- The *for loop* construct allows us to express repetitive patterns in a structured way.

The For-loop

- The For-loop is a *control statement*.
  - Doesn't do anything on its own, but instead *controls* the execution of other statements.



For-loop Semantics



Our Example, Step-by-step (1)

```
public class Cubes {
  public static void main(String[] args) {
    for (int i = 0; i < 5; i++) {
      System.out.println(i + "^3 = " + i * i * i);
    }
  }
}
```

Iteration #	Value of *i*	Test	Output

Our Example, Step-by-step (2)

```
public class Cubes {
  public static void main(String[] args) {
    for (int i = 0; i < 5; i++) {
      System.out.println(i + "^3 = " + i * i * i);
    }
  }
}
```

Iteration #	Value of *i*	Test	Output
1	0	0 < 5 is *true*	0^3 = 0

Our Example, Step-by-step (3)

```
public class Cubes {
  public static void main(String[] args) {
    for (int i = 0; i < 5; i++) {
      System.out.println(i + "^3 = " + i * i * i);
    }
  }
}
```

Iteration #	Value of *i*	Test	Output
1	0	0 < 5 is *true*	0^3 = 0
2	1	1 < 5 is *true*	1^3 = 1

Our Example, Step-by-step (4)

```
public class Cubes {
  public static void main(String[] args) {
    for (int i = 0; i < 5; i++) {
      System.out.println(i + "^3 = " + i * i * i);
    }
  }
}
```

Iteration #	Value of *i*	Test	Output
1	0	0 < 5 is *true*	0^3 = 0
2	1	1 < 5 is *true*	1^3 = 1
3	2	2 < 5 is *true*	2^3 = 8

Our Example, Step-by-step (5)

```
public class Cubes {
  public static void main(String[] args) {
    for (int i = 0; i < 5; i++) {
      System.out.println(i + "^3 = " + i * i * i);
    }
  }
}
```

Iteration #	Value of *i*	Test	Output
1	0	0 < 5 is *true*	0^3 = 0
2	1	1 < 5 is *true*	1^3 = 1
3	2	2 < 5 is *true*	2^3 = 8
4	3	3 < 5 is *true*	3^3 = 27

Our Example, Step-by-step (6)

```
public class Cubes {
  public static void main(String[] args) {
    for (int i = 0; i < 5; i++) {
      System.out.println(i + "^3 = " + i * i * i);
    }
  }
}
```

Iteration #	Value of *i*	Test	Output
1	0	0 < 5 is *true*	0^3 = 0
2	1	1 < 5 is *true*	1^3 = 1
3	2	2 < 5 is *true*	2^3 = 8
4	3	3 < 5 is *true*	3^3 = 27
5	4	4 < 5 is *true*	4^3 = 64

Our Example, Step-by-step (7)

```
public class Cubes {
  public static void main(String[] args) {
    for (int i = 0; i < 5; i++) {
      System.out.println(i + "^3 = " + i * i * i);
    }
  }
}
```

Iteration #	Value of *i*	Test	Output
1	0	0 < 5 is *true*	0^3 = 0
2	1	1 < 5 is *true*	1^3 = 1
3	2	2 < 5 is *true*	2^3 = 8
4	3	3 < 5 is *true*	3^3 = 27
5	4	4 < 5 is *true*	4^3 = 64
6	5	5 < 5 is *false*	

For-loop Bounds

- Different sorts of bounds are possible!

```
for (int i = 1; i <= 5; i++) {
  System.out.print(i + " ");
}
```
Output: 1 2 3 4 5

```
for (int i = 5; i > 0; i--) {
  System.out.print(i + " ");
}
```
Output: 5 4 3 2 1

```
for (int i = 256; i > 0; i /= 2) {
  System.out.print(i + " ");
}
```
Output: 256 128 64 32 16 8 4 2 1

```
for (int i = -3; i < 10; i += 2) {
  System.out.print(i + " ");
}
```
Output: -3 -1 1 3 5 7 9

"<" versus "<=" Bounds

- "i = 0; i < 5" versus "i = 1; i <= 5":
  - Both give 5 loop iterations.
  - "i = 0, 1, 2, 3, 4" versus "i = 1, 2, 3, 4, 5".
- "i = 0; i < 5" is *less intuitive*, *more canonical*
  - Most computations are naturally *zero-based*.
  - For homework 2, either is fine.
    - Try to get used to the zero-based style.

Yo Dawg, I Heard You Liked Loops

- Problem: draw a rectangle of stars.

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

Solution: Loopception

```
public class Rectangle {
  public static void main(String[] args) {
    // The outer for-loop controls the #/lines
    for (int i = 0; i < 5; i++) {
      // The inner for-loop controls the
      // contents of a single line.
      for (int j = 0; j < 5; j++) {
        System.out.print("*");
      }
      System.out.println();
    }
  }
}
```


Careful with Your Nested Loop Bounds!

```
for (int i = 0; i < 5; i++) {
  for (int j = 0; j < 5; j++) {
    System.out.print("*");
  }
  System.out.println();
}
```

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

```
for (int i = 0; i < 5; i++) {
  for (int j = 0; j < i; j++) {
    System.out.print("*");
  }
  System.out.println();
}
```

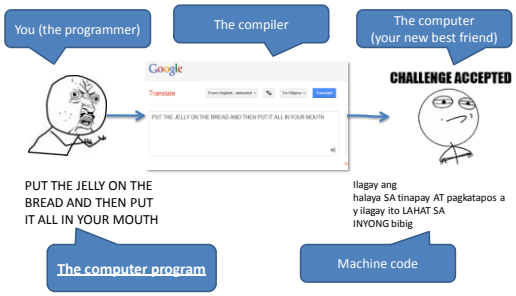
```
*
**
***
****
```

```
for (int i = 0; i < 5; i++) {
  for (int j = 0; j < 5; i++) {
    System.out.print("*");
  }
  System.out.println();
}
```

```
Infinite loop!
```


Algorithm Design and Pseudocode

Remember Compilation?



English is Still Useful!

- Sometimes it is difficult to write an algorithm/computer program directly.

Problem:

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

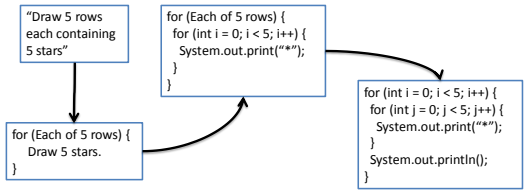
"Draw 5 rows each containing 5 stars"

/* ??? */

Pseudocode!

Pseudocode Helps Organize Your Thoughts

- Stuck and don't know how to make progress?
  - Write an *English* description of your solution.
  - Transform that English description into code.



By Example: A Cone

- Problem: draw the following cone shape.

```
  /\
 /--\
/----\
/------\
/--------\
```

"Draw 5 rows each containing a section of the cone."

```
for (int i = 0; i < 5; i++) {
  Draw a section of the cone
  System.out.println();
}
```


Cone Sections

- Each line has the following form:
  - `<spaces> / <dashes> \`
  - Let's find the pattern for each part!

```
  /\
 /--\
/----\
/------\
/--------\
```

Iteration/row (i)	Spaces	/	Dashes	\
0	4	1	0	1
1	3	1	2	1
2	2	1	4	1
3	1	1	6	1
4	0	1	8	1

- Formula for spaces: `4 - i`
- Formula for dashes: `i * 2`

From Tables to Code

```
for (int i = 0; i < 5; i++) {
  Draw a section of the cone
  System.out.println();
}
```

```
for (int i = 0; i < 5; i++) {
  Draw spaces
  Draw /
  Draw dashes
  Draw \
  System.out.println();
}
```

```
for (int i = 0; i < 5; i++) {
  for (int j = 0; j < 4 – i; j++) {
    System.out.print(" ");
  }
  System.out.print("/");
  for (int j = 0; j < i * 2; j++) {
    System.out.print("-");
  }
  System.out.print("\\");
  System.out.println();
}
```


Stop Being So Constant

- What value controls the height of the cone?

```
for (int i = 0; i < 5; i++) {
  for (int j = 0; j < 4 – i; j++) {
    System.out.print(" ");
  }
  System.out.print("/");
  for (int j = 0; j < i * 2; j++) {
    System.out.print("-");
  }
  System.out.print("\\");
  System.out.println();
}
```

The height of the cone but not immediately obvious! An example of a *magic number*.

Surprise! An *indirect use* of the height of the cone. If we change the height, then this number needs to change as well!

(Bad) Example: Quake III Arena

```
float Q_rsqrt( float number )
{
  long i;
  float x2, y;
  const float threehalfs = 1.5F;

  x2 = number * 0.5F;
  y  = number;
  i  = * ( long * ) &y;
  i  = 0x5f3759df - ( i >> 1 );
  y  = * ( float * ) &i;
  y  = y * ( threehalfs - ( x2 * y * y ) );   // 1st iteration
//   y  = y * ( threehalfs - ( x2 * y * y ) );   // 2nd iteration, this can be removed

  return y;
}
```

- *Note:* code is written in C but should be (somewhat) understandable!
- This is the exact source from the game!
- The constant was a source of much debate! See Fast Inverse Square Root @ Wikipedia for more details.

```
  // evil floating point bit level hacking
  // what the fuck?
```

Solution to Magic Numbers: Class Constants

- Class constants let us "document" magic numbers by naming them and giving us a central place to change their values if necessary.

```
public class Cone {
  public static final int HEIGHT = 5;
    public static void main(String[] args) {
    for (int i = 0; i < HEIGHT; i++) {
      for (int j = 0; j < (HEIGHT - 1) - i; j++) {
        System.out.print(" ");
      }
      System.out.print("/");
      for (int j = 0; j < i * 2; j++) {
        System.out.print("-");
      }
      System.out.print("\\");
      System.out.println();
    }
  }
}
```


Syntax of Class Constants

```
public class Cone {
  public static final int HEIGHT = 5;
    public static void main(String[] args) {
    for (int i = 0; i < HEIGHT; i++) {
/* Snip! */
```

- Constants are declared *outside of methods* but *inside the class*.
  - `public static final <type> <name> = <value>;`
- Constants are variables that cannot be reassigned.
- Convention is to NAME_THEM_LIKE_THIS.