**Announcements**

- **Assignments:**
  - Homework 0 grades up
  - Program 1 due yesterday
  - Program 2 due Monday
  - Program 3 assigned today

- Updated yesterday’s slides
Questions?
Today in COMP 110

- Loops
  - Body
  - Initializing Statements
  - Ending a loop
  - Bugs
Loop Body

count = 1;
while (count <= num) {
  System.out.print(count + "", ");
  count++;
}

- Repeated code
- Write pseudocode and turn repeated statements into loops
Pseudocode for loop

- Get user input
- sum = sum + input
- Get user input
- sum = sum + input
- Get user input
- sum = sum + input
- Average sum

Repeated statements in pseudocode become your loop
Body of our loop

- Get user input
- sum = sum + input
Initializing Statements

\[ \text{sum} = \text{sum} + \text{input} \]

- Variables in your loop must be initialized (set to a value) before the loop.

- What is initialization of sum?
Initializing Statements

sum = sum + input

- Variables in your loop must be initialized (set to a value) before the loop

- What is initialization of sum?

- What if we wanted the product?
  - sum = sum * input
Ending a loop

- If you know number of loop iterations?
  - Count-controlled loops
    - `for(count = 0; count < iterations; count++)`
  - User controlled ending
    - Ask-before-iterating
    - Sentinel value
- Booleans
for (count = 0; count < iterations; count++) {
    System.out.print("I have iterated");
    System.out.println((count + 1) + " times");
}
do {

    //do stuff in your code here

    System.out.print( "Continue? yes/no");
    answer = keyboard.next();
} while (answer.equalsIgnoreCase("yes"));
Signal end of input
System.out.print("enter a negative number to end the loop");
next = keyboard.nextInt();
sum = 0;
while ( next >= 0 ) {
    sum = sum + next;
    System.out.print("Enter a number: ");
    next = keyboard.nextInt();
}
```java
int next, sum = 0;
boolean numbersLeft = true;
Scanner keyboard = new Scanner(System.in);
while (numbersLeft) {
    next = keyboard.nextInt();
    if (next < 0) {
        numbersLeft = false;
    } else {
        sum = sum + next;
    }
}
System.out.println("the sum is " + sum);
```
Booleans

```java
int count, count2;
for (count = 0; count <= 3; count++) {
    for (count2 = 0; count2 < count; count2++) {
        System.out.println(count2);
    }
}
```

Output:

Value of count: 1
Value of count2: 0

Value of count: 2
Value of count2: 0, 1

Value of count: 3
Value of count2: 0, 1, 2
int count, count2;
for (count = 0; count <= 3; count++) {
    for (count2 = 0; count2 < count; count2++) {
        System.out.println(count2);
    }
}

Output:

<table>
<thead>
<tr>
<th>Value of count:</th>
<th>0</th>
</tr>
</thead>
<tbody>
<tr>
<td>Value of count2:</td>
<td></td>
</tr>
</tbody>
</table>
int count, count2;
for (count = 0; count <= 3; count++) {
    for (count2 = 0; count2 < count; count2++) {
        System.out.println(count2);
    }
}

Output:

Value of count: 0
Value of count2:
Booleans

```java
int count, count2;
for (count = 0; count <= 3; count++) {
    for (count2 = 0; count2 < count; count2++) {
        System.out.println(count2);
    }
}
```

Output:

Value of count:
- 0

Value of count2:
- 0
int count, count2;
for (count = 0; count <= 3; count++) {
    for (count2 = 0; count2 < count; count2++) {
        System.out.println(count2);
    }
}

Output:

<table>
<thead>
<tr>
<th>Value of count:</th>
<th>0</th>
</tr>
</thead>
<tbody>
<tr>
<td>Value of count2:</td>
<td>0</td>
</tr>
</tbody>
</table>
```java
int count, count2;
for (count = 0; count <= 3; count++) {
    for (count2 = 0; count2 < count; count2++) {
        System.out.println(count2);
    }
}
```

Output:

<table>
<thead>
<tr>
<th>Value of count:</th>
<th>1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Value of count2:</td>
<td>0</td>
</tr>
</tbody>
</table>
int count, count2;
for (count = 0; count <= 3; count++) {
    for (count2 = 0; count2 < count; count2++) {
        System.out.println(count2);
    }
}

Output:

<table>
<thead>
<tr>
<th>Value of count:</th>
<th>1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Value of count2:</td>
<td>0</td>
</tr>
</tbody>
</table>
```java
int count, count2;
for (count = 0; count <= 3; count++) {
    for (count2 = 0; count2 < count; count2++) {
        System.out.println(count2);
    }
}
```

Output:

<table>
<thead>
<tr>
<th>Value of count:</th>
<th>1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Value of count2:</td>
<td>0</td>
</tr>
</tbody>
</table>
```java
int count, count2;
for (count = 0; count <= 3; count++) {
    for (count2 = 0; count2 < count; count2++) {
        System.out.println(count2);
    }
}
```

Output:

Value of count: 1
Value of count2: 0
Booleans

```java
int count, count2;
for (count = 0; count <= 3; count++) {
    for (count2 = 0; count2 < count; count2++) {
        System.out.println(count2);
    }
}
```

Output:

<table>
<thead>
<tr>
<th>Value of count:</th>
<th>1</th>
</tr>
</thead>
<tbody>
<tr>
<td>Value of count2:</td>
<td>0</td>
</tr>
</tbody>
</table>
```java
int count, count2;
for (count = 0; count <= 3; count++) {
    for (count2 = 0; count2 < count; count2++) {
        System.out.println(count2);
    }
}
```

Output:

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td></td>
</tr>
</tbody>
</table>

Value of count: 1
Value of count2: 1
Booleans

```java
int count, count2;
for (count = 0; count <= 3; count++) {
    for (count2 = 0; count2 < count; count2++) {
        System.out.println(count2);
    }
}
```

<table>
<thead>
<tr>
<th>Output:</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
</tr>
</tbody>
</table>

Value of count: 1
Value of count2: 1
Booleans

```java
int count, count2;
for (count = 0; count <= 3; count++) {
    for (count2 = 0; count2 < count; count2++) {
        System.out.println(count2);
    }
}
```

<table>
<thead>
<tr>
<th>Value of count:</th>
<th>2</th>
</tr>
</thead>
<tbody>
<tr>
<td>Value of count2:</td>
<td>1</td>
</tr>
</tbody>
</table>
```java
int count, count2;
for (count = 0; count <= 3; count++) {
    for (count2 = 0; count2 < count; count2++) {
        System.out.println(count2);
    }
}
```

<table>
<thead>
<tr>
<th>Output:</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
</tr>
</tbody>
</table>

Value of count: 2
Value of count2: 1
```java
int count, count2;
for (count = 0; count <= 3; count++) {
    for (count2 = 0; count2 < count; count2++) {
        System.out.println(count2);
    }
}
```

**Value of count:**

| 2 |

**Value of count2:**

| 0 |

**Output:**

| 0 |
Booleans

```java
int count, count2;
for (count = 0; count <= 3; count++) {
    for (count2 = 0; count2 < count; count2++) {
        System.out.println(count2);
    }
}
```

Output:

Value of count: 2
Value of count2: 0
```java
int count, count2;
for (count = 0; count <= 3; count++) {
    for (count2 = 0; count2 < count; count2++) {
        System.out.println(count2);
    }
}
```

Output:

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td></td>
</tr>
<tr>
<td>0</td>
<td></td>
</tr>
</tbody>
</table>

Value of count: 2
Value of count2: 0
Booleans

```java
int count, count2;
for (count = 0; count <= 3; count++) {
    for (count2 = 0; count2 < count; count2++) {
        System.out.println(count2);
    }
}
```

Output:

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

Value of count: 2
Value of count2: 1
```java
int count, count2;
for (count = 0; count <= 3; count++) {
    for (count2 = 0; count2 < count; count2++) {
        System.out.println(count2);
    }
}
```

Output:

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

Value of count: 2
Value of count2: 1
Booleans

```java
int count, count2;
for (count = 0; count <= 3; count++) {
    for (count2 = 0; count2 < count; count2++) {
        System.out.println(count2);
    }
}
```

<table>
<thead>
<tr>
<th>Output:</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
</tr>
<tr>
<td>0</td>
</tr>
<tr>
<td>1</td>
</tr>
</tbody>
</table>

Value of count: 2
Value of count2: 1
int count, count2;
for (count = 0; count <= 3; count++) {
    for (count2 = 0; count2 < count; count2++) {
        System.out.println(count2);
    }
}

Output:
0
0
1

Value of count: 2
Value of count2: 2
### Booleans

```java
int count, count2;
for (count = 0; count <= 3; count++) {
    for (count2 = 0; count2 < count; count2++) {
        System.out.println(count2);
    }
}
```

<table>
<thead>
<tr>
<th>Output:</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
</tr>
<tr>
<td>0</td>
</tr>
<tr>
<td>1</td>
</tr>
</tbody>
</table>

Value of count: 2
Value of count2: 2
int count, count2;
for (count = 0; count <= 3; count++) {
    for (count2 = 0; count2 < count; count2++) {
        System.out.println(count2);
    }
}

<table>
<thead>
<tr>
<th>Output:</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
</tr>
<tr>
<td>0</td>
</tr>
<tr>
<td>1</td>
</tr>
</tbody>
</table>

Value of count: 3
Value of count2: 2
Booleans

```java
int count, count2;
for (count = 0; count <= 3; count++) {
    for (count2 = 0; count2 < count; count2++) {
        System.out.println(count2);
    }
}
```

Output:

<table>
<thead>
<tr>
<th>Output:</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
</tr>
<tr>
<td>0</td>
</tr>
<tr>
<td>1</td>
</tr>
</tbody>
</table>

Value of count: 3
Value of count2: 2
Booleans

```java
int count, count2;
for (count = 0; count <= 3; count++) {
    for (count2 = 0; count2 < count; count2++) {
        System.out.println(count2);
    }
}
```

<table>
<thead>
<tr>
<th>Output:</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>1</td>
</tr>
</tbody>
</table>

Value of count: 3
Value of count2: 0
```java
int count, count2;
for (count = 0; count <= 3; count++) {
    for (count2 = 0; count2 < count; count2++) {
        System.out.println(count2);
    }
}

Value of count: 3
Value of count2: 0
```

Output:

<p>| |</p>
<table>
<thead>
<tr>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
</tr>
<tr>
<td>0</td>
</tr>
<tr>
<td>1</td>
</tr>
</tbody>
</table>
```java
int count, count2;
for (count = 0; count <= 3; count++) {
    for (count2 = 0; count2 < count; count2++) {
        System.out.println(count2);
    }
}
```

Output:

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td></td>
<td>0</td>
</tr>
</tbody>
</table>

Value of count: 3
Value of count2: 0
Booleans

```java
int count, count2;
for (count = 0; count <= 3; count++) {
    for (count2 = 0; count2 < count; count2++) {
        System.out.println(count2);
    }
}
```

<table>
<thead>
<tr>
<th>Output:</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
</tr>
<tr>
<td>0</td>
</tr>
<tr>
<td>1</td>
</tr>
<tr>
<td>0</td>
</tr>
</tbody>
</table>

Value of count: 3
Value of count2: 1
Booleans

```java
int count, count2;
for (count = 0; count <= 3; count++) {
    for (count2 = 0; count2 < count; count2++) {
        System.out.println(count2);
    }
}
```

<table>
<thead>
<tr>
<th>Output:</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
</tr>
<tr>
<td>0</td>
</tr>
<tr>
<td>1</td>
</tr>
<tr>
<td>0</td>
</tr>
</tbody>
</table>

Value of count: 3

Value of count2: 1
int count, count2;
for (count = 0; count <= 3; count++) {
    for (count2 = 0; count2 < count; count2++) {
        System.out.println(count2);
    }
}

Value of count: 3
Value of count2: 1

Output:
0
0
1
0
1
int count, count2;
for (count = 0; count <= 3; count++) {
    for (count2 = 0; count2 < count; count2++) {
        System.out.println(count2);
    }
}

Value of count: 3
Value of count2: 2

Output:
0
0
1
0
1
int count, count2;
for (count = 0; count <= 3; count++) {
    for (count2 = 0; count2 < count; count2++) {
        System.out.println(count2);
    }
}

Value of count: 3
Value of count2: 2

Output:
  0
  0
  1
  0
  1
int count, count2;
for (count = 0; count <= 3; count++) {
    for (count2 = 0; count2 < count; count2++) {
        System.out.println(count2);
    }
}

Value of count: 3
Value of count2: 2

Output:
0
0
1
0
1
2
```java
int count, count2;
for (count = 0; count <= 3; count++) {
    for (count2 = 0; count2 < count; count2++) {
        System.out.println(count2);
    }
}
```

<table>
<thead>
<tr>
<th>Output:</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
</tr>
<tr>
<td>0</td>
</tr>
<tr>
<td>1</td>
</tr>
<tr>
<td>0</td>
</tr>
<tr>
<td>1</td>
</tr>
<tr>
<td>2</td>
</tr>
</tbody>
</table>

Value of count: 3
Value of count2: 3
Booleans

```java
int count, count2;
for (count = 0; count <= 3; count++) {
    for (count2 = 0; count2 < count; count2++) {
        System.out.println(count2);
    }
}
```

Value of count: 3
Value of count2: 3

Output:

<p>| | | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>1</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>2</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
int count, count2;
for (count = 0; count <= 3; count++) {
    for (count2 = 0; count2 < count; count2++) {
        System.out.println(count2);
    }
}

<table>
<thead>
<tr>
<th>Output:</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
</tr>
<tr>
<td>0</td>
</tr>
<tr>
<td>1</td>
</tr>
<tr>
<td>0</td>
</tr>
<tr>
<td>1</td>
</tr>
<tr>
<td>2</td>
</tr>
</tbody>
</table>

Value of count: 4
Value of count2: 3
Booleans

int count, count2;
for (count = 0; count <= 3; count++) {
    for (count2 = 0; count2 < count; count2++) {
        System.out.println(count2);
    }
}

<table>
<thead>
<tr>
<th>Output:</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
</tr>
<tr>
<td>0</td>
</tr>
<tr>
<td>1</td>
</tr>
<tr>
<td>0</td>
</tr>
<tr>
<td>1</td>
</tr>
<tr>
<td>2</td>
</tr>
</tbody>
</table>

Value of count: 4
Value of count2: 3
```java
int count, count2;
for (count = 0; count <= 3; count++) {
    for (count2 = 0; count2 < count; count2++) {
        System.out.println(count2);
    }
}

Value of count: 4
Value of count2: 3
```

Output:
```
0
0
1
0
1
2
```
Give a Java loop statement that will set the variable \texttt{result} equal to $2^5$. 
Bugs

- Problem with program preventing correct execution

- Two most common mistake in loops
  - Off-by-one errors
  - Infinite Loops!!!!!!
Off-by-one errors

- Loop repeats one too many or one too few times

```java
for (count = 1; count < 10; count++);
```
- Loop 9 times

  - Loop 9 times
Infinite Loops

- A loop which repeats without ever ending is called an infinite loop.

- If the controlling boolean expression never becomes false, a loop will repeat without ending.
count = 1;
while (count <= num)
{
    System.out.print(count + "", "");
    //count++;
}
Infinite Loops

count = 1;
while (count <= num);
{
    System.out.print(count + " ", ");
    count++;
}

int count;
// initializing action; boolean expression; update action
for (count = 1; count >= num; count++)
{
    System.out.print(count + " , ");
}
Finding errors

- Error checking
  - System.out.print(variable);
  - Run on simple input

- Debugger