# Repetition Statements (Loops)

CS 99 – Summer 2000

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Lecture 5

## Administration

- Prelim 1 Review Session Tonight
  - 7:30-8:30pm
  - Upson 211
  - Bring questions or it will be over quickly!
- Lab 4 in progress, due tomorrow
- Lab 5 posted today
- Prelim 1 on Wednesday in class, covers:
  - Lectures & Labs 1-4
  - assigned reading (esp. 1.2, 1.4, 1.5, 2.2, 2.4)

## Agenda

- Repetition statements
- Three repetitions statements in Java:
  - `for`
  - `while`
  - `do`

## Repetition

- Computers are great at performing repeated tasks
- So far, we don't know how to repeat tasks (conveniently) in a program
- Examples:
  - Add all the integers from 1 to 100
  - Calculate grades for an entire class

## Repetition [2]

- The three statements for repetition in Java are:

```
for(…; …; …) {
    …
}
```

```
while(…) {
    …
}
```

```
do {
    …
} while(…);
```

- Most loops share these characteristics:
  - a variable is assigned some value before the loop
  - the variable's value changes at some point in the loop
  - repetition continues until some condition is true (e.g., the variable reaches some predetermined value)

## Repetition [3]

- Pretest loop: a loop that uses a condition to control whether or not the body of the loop is executed *before* going through the loop
  - condition is true, body is executed
  - condition is false, body is skipped
  - `while`, `for`
- Posttest loop: executes the body of the loop, then checks a condition to decide whether to execute it again
  - condition is true, body is executed again, and condition checked again
  - condition is false, move on to next executable statement
  - `do`

## Repetition [4]

- Variable repetition: the number of times the loop body will execute is unknown
  - e.g., adding numbers the user enters until the sum is greater than 100
  - `while, do`
- Fixed repetition: the number of times the loop body will execute is predetermined (but not nec. constant)
  - e.g., adding integers from 1 to 100
  - `for, (while, do)`

## Repetition [5]

- `while`, `do`, and `for` loops are all equivalent in that each can be rewritten as the others
  - though it may require the addition of one or more statements
- However, each loop is more appropriate at different times, based on whether you want fixed or variable repetition, and pretests or posttests

## `for` Loops

- The `for` loop is:
  - pretest
  - fixed repetition
  - A convenient structure for writing certain types of loops more concisely than `while` allows
- It combines 3 statements into one

## First `for`

```
// sum the integers from 1 to 100
sum = 0;
for (i = 1; i <= 100; i++) {
    sum = sum + i;
}
```

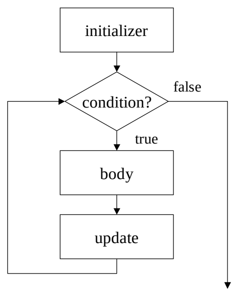
- Execution:
  - Initialize `i` to 1
  - Check if `i` is less than or equal to 100
    - If so, execute body
    - If not, stop repeating
  - Update `i` by incrementing it
  - Repeat

## Syntax of `for`

```
for (initializer; condition; update) {
  ...
}
```

- *initializer* and *update* are statements
  - *initializer* can be a variable declaration, with scope through the end of the block that the `for` statement is in
- *condition* is a boolean expression
- the first line is called the *loop header*

## Control Flow of `for`



## Common for loops

```
// count from low to high using var
for (int var = low; var <= high; var++) {
   ...
}

// count from high down to low using var
for (int var = high; var >= low; var--) {
   ...
}
```

These types of `for` loops should never change the value of *var* inside of the body!

## for Example #1

- Print the numbers 1-10 along with their squares and cubes

```
for (int i = 1; i <= 10; i++) {
  System.out.println(i + “\t” + i*i + “\t” +
                      i*i*i);
}
```

## for Example #2

- Average a set of numbers entered by the user. Begin by inputting how many numbers are in the set.

```
System.out.print(“Enter how many numbers there are: ”);
int size = Console.readInt();
int sum = 0;
for (int i = 1; i <= size; i++) {
  System.out.print(“Enter #” + i + “: ”);
  sum += Console.readInt();
}
double average = (double) sum / size;
```

## for Example #3

- Sum the multiples of 7 between 1 and 1000

```
int sum = 0;
for (int num = 7; num <=1000; num += 7) {
  sum += num;
}
```

A variable used in a loop to keep a sum of the value of some other variable is called an *accumulator*.

The variable that is declared, checked, and updated is called the *loop index* or *loop control variable*.

## for Example #4

- Use a `for` loop to produce the following output:

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

## for Example #4 [2]

```
for (int spaces = 3; spaces >= 0; spaces--) {
  for (int i = 1; i <= spaces; i++) {
     System.out.print(“ ”);
  }
  System.out.println(“***”);
}
```

## `while` Loops

- The `while` loop is:
  - pretest
  - variable repetition
  - very similar to an `if` statement

## First `while`

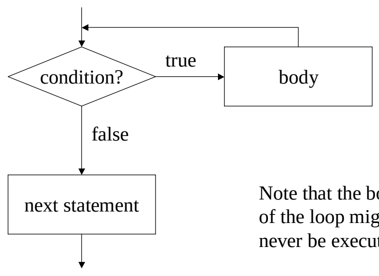
```
int num = 1, sum = 0;
while (num <= 100) {
  sum = sum + num;
  num++;
}
```

## Syntax and Semantics of `while`

```
while (boolean-expression) {
  ...
}
```

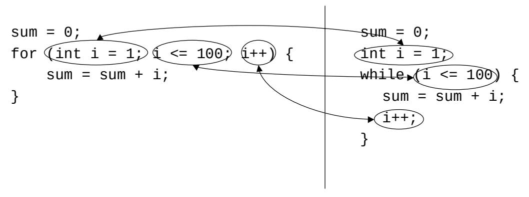
- Evaluate the expression
- If it is true, execute the body of the loop and repeat
- If it is false, transfer control to the next statement after the loop

## Flow of Control of `while`



Note that the body of the loop might never be executed.

## Rewriting `for` as `while`



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

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

## `while` Example #1

- Determine how many powers of two are between 0 and 100 and print each of them

```
count = 0;   // counter variable
pow2 = 1;
while (pow2 < 100) {
  System.out.println(pow2);
  pow2  = pow2 * 2;
  count++;
}
System.out.println("There are " + count + " powers of 2
  less than 100.");
```

## `while` Example #2

- A sentinel is an input value than indicates the end of input
  - e.g., “Enter a number, -999 to quit: ”
- Average a set of numbers input from the user, terminated by a sentinel

## `while` Example #2 [2]

```
int count = 0;
int sum = 0;
System.out.print(“Enter a number, -1 to quit: ”);
int num = Console.readInt();
while (num != -1) {
  count++;
  sum += num;
  System.out.print(“Enter a number, -1 to quit”);
  int num = Console.readInt();
}
if (count > 0) {
  double average = (double) sum / count;
  System.out.println(“average = ” + average);
}
```

## `while` Example #3

- What’s wrong with this loop?

```
// print powers of 3 between 1 and 100
pow3 = 1;
while (pow3 != 100) {
  System.out.println(pow3);
  pow3 = pow3 * 3;
}
```

## `while` Example #3 [2]

- Infinite loop, should be:

```
// print powers of 3 between 1 and 100
pow3 = 1;
while (pow3 < 100) {
  System.out.println(pow3);
  pow3 = pow3 * 3;
}
```

## `while` Example #4

- What’s wrong with this loop?

```
// print the first five powers of 3 between
// 1 and x, inclusive
pow3 = 1;
count = 1;
while (count <= 5 && pow3 <= x) {
  System.out.println(pow3);
  pow3 = pow3 * 3;
}
```

## `while` Example #4 [2]

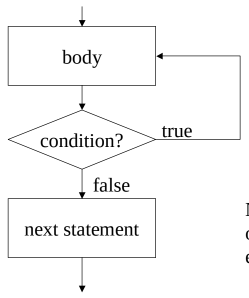
- Again, an infinite loop, should be:

```
// print the first five powers of 3 between
// 1 and x, inclusive
pow3 = 1;
count = 1;
while (count <= 5 && pow3 <= x) {
  System.out.println(pow3);
  pow3 = pow3 * 3;
  count++;
}
```

## do Loops

- Syntax:
```
do {
    ...
} while (boolean-expression);
```
- Semantics:
  - Execute the body
  - Check the condition
    - If true, repeat
    - If false, transfer control to the statement after the loop

## Flow of control in do



Note that the body of the loop is always executed at least once.

## do Example #1

- Average a set of numbers input from the user, terminated by a sentinel

```
int count = 0;
int sum = 0;
do {
   System.out.print(“Enter a number, -999 to quit: ”);
   int num = Console.readInt();
   if (num != -999) {
        count++;
        sum += num;
   }
} while (num != -999);
if (count > 0) {
   double average = (double) sum / count;
   System.out.println(“average = ” + average);
}
```

## do Example #2

- Data validation
- Prompt the user for a yes or no answer, and keep prompting until the user enters either “yes” or “no”.

```
String response;
do {
   System.out.println(“Do you wish to continue? ”
                     + “(yes or no): ”);
   response = Console.readString();
} while ( !(   response.equals(“yes”)
            || response.equals(“no”)) );
```