Repetition Structures: for, while, do…while

CCS1110
Programming
Principles and Algorithms

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Lecture Outline

- Repetition Structures (loops)
- for loop
- while loop
  - Counter-controlled repetition
  - Sentinel-controlled repetition
- do...while loop
- More operators: Increment & decrement
- Top-down stepwise refinement

Repetition Structures (loops)

- Repetition Structures (loops) allow the execution of a block of code multiple times
- There are 3 repetition structures in Java:
  - **for**
    - Repeat **for** a particular number of times
  - **while**
    - Repeat **while** a condition is true
    - (condition is checked at the beginning)
  - **do…while**
    - Execute the commands once **(do …)** and then repeat **while** a condition is true
    - (condition is checked at the end)
- All repetition structures are equivalent:
  - A while loop can be written as a for loop, etc.

`for` Repetition Structure

- Used when the number of repetitions is known
- General syntax:

```
for (counter_initialisation; condition; counter_update){
   <body_of_statements>
}
```

- where:
  - **counter_initialisation** initialises a variable that will act as a counter
  - **condition** is a boolean expression that represents the check that is performed before each repetition to determine whether the body of statements will be executed once more
  - **counter_update** is a statement that modifies the counter at the end of each repetition

`for` Example 1:

- Print the numbers 0, 1, …, 5

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

Output on the Screen:

```
0
1
2
3
4
5
```


`for` Example 2:

- Find one power of a number

```
int number = 3;     //the number…
int power = 4;      // …to the power of
int result = 1;     // initial value of the result

for (int i = 0; i < power; i++)
{
        result = result * number;
}
String output = number + " to the power of " + power + " is " + result;
System.out.println(output);
```

Output on the Screen:

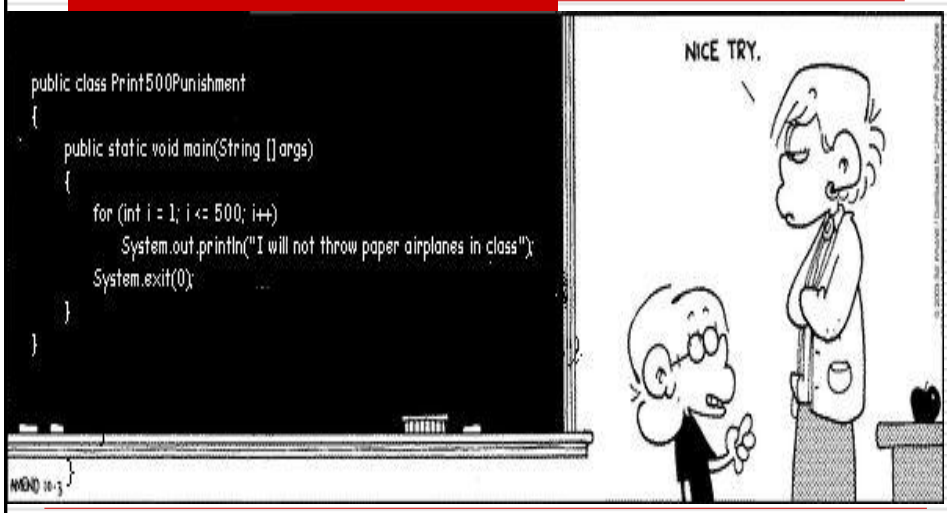
```
3 to the power of 4 is 81;
```

`for` Example 3

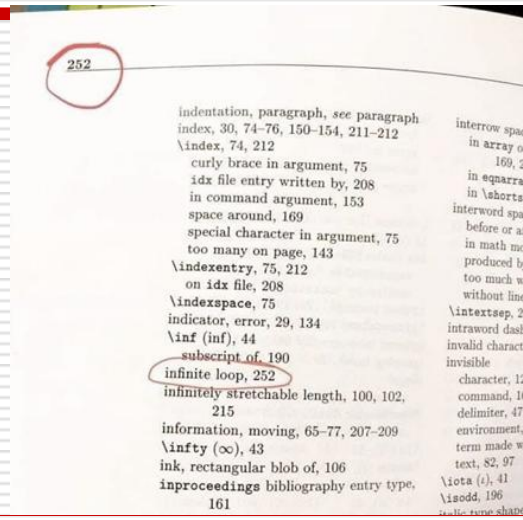
- Extend the previous code so that it finds the first 10 powers of the numbers 1-10

```
int power = 10;      // …to the power of
int result;

for (int number = 1; number <= 10; number++)
{
    result = 1; // initial value of the result for each number

    for (int i = 0; i < power; i++)
    {
        result = result * number;
    }

    String output = number + " to the power of " + power + " is " + result;
    System.out.println(output);
}
```


Repetitions are useful…



…as long as they terminate at some point….



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indentation, paragraph, *see* paragraph
index, 30, 74–76, 150–154, 211–212
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infinite loop, 252
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information, moving, 65–77, 207–209
\infty (∞), 43
ink, rectangular blob of, 106
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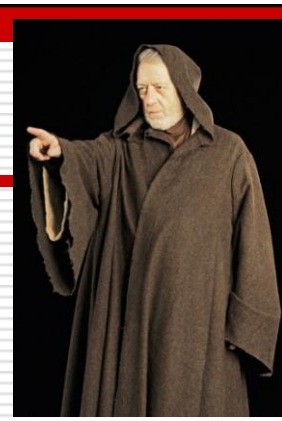

May the FORs be with you

`while` Repetition Structure

- Used when the number of repetitions is unknown and depends on a condition
- General Syntax:

```
while(condition){
    <body_of_statements>
}

// it will repeat (execute) the loop (body of statements)
// while (as long as) the condition is true
```


`while` Example 1

- Find the first power of 2 that is greater than 1000

```
// LET'S THINK ABOUT THE SOLUTION

// The result is a product that will be calculated incrementally:
// We initialize to 1(neutral element of multiplication)

//while this product is less or equal to 1000

        // we multiply it by 2 (to get the next power of 2)


// at the end we print the result (product)
```

`while` Example 1 (cont'd)

```
// LET'S JAVA !

// The result is a product that will be calculated incrementally:
// We initialize to 1(neutral element of multiplication)
int product = 1 ;

//while this product is less or equal to 1000
while ( product <= 1000 )
{
        // we multiply it by 2 (to get the next power of 2)
        product = 2 * product ;
}

// at the end we print the result (product)
System.out.println("The 1st power of 2 that is greater than 1000
                                                    is: " + product);
```


`while`: sentinel-controlled repetition

- In cases where repetition termination depends on the user, a special value, called the **sentinel** value, must be used
- **Be careful** which value you choose as a sentinel; it must not be a valid value!

`while` Example 2 (sentinel-controlled repetition)

- Find the sum of all the numbers that the user enters
  - Zero is selected as the sentinel value

```
//LET'S THINK ABOUT THE SOLUTION

// we need one variable for the user number and one for the sum (result)

//while the user number is not 0 (sentinel value is 0)
   // add the number to sum
   // prompt again for a number

// at the end print the sum
```


`while` Example 2 (cont'd)

```
//LET'S JAVA

// we need one variable for the user number and one for the sum (result)
int number;
int sum = 0 ;
Scanner scanner = new Scanner(System.in);

// prompt for the 1st number before the loop
// (because it is used in the condition of the while loop that follows)
System.out.println("Enter an integer number (0 to stop)");
number = scanner.nextInt();

//while the user number is not 0 (sentinel value is 0)
while ( number != 0 ) {
   // add the number to sum
   sum += number ;
   // prompt again for a number
   System.out.println("Enter a positive number (0 to stop)");
   number = scanner.nextInt();
}
// at the end print the sum
System.out.println("The sum of all entered numbers is: " + sum);
```

`while` Example 3

Expand the previous code so that it also displays at the end:

- how many numbers have been entered, and
- their average

```
int number;
int sum = 0;
// we need one more variable for the average, and a counter
// (we have to count the numbers to calculate the average)
double average;
int count;

Scanner scanner = new Scanner(System.in);
System.out.print("Enter an integer number (0 to stop)");
number = scanner.nextInt();

while (number != 0) {
   sum += number;
   count++; // increase the counter when a number is added
   System.out.print("Enter an integer number (0 to stop)");
   number = scanner.nextInt();
}
// make sure the user entered at least one number
if (count != 0 ) {
   average = (double) sum / count; // find the average
   System.out.println(count + " numbers entered");
   System.out.println("Sum : " + sum) ;
   System.out.println("Average : " + average) ;
}
else {
   System.out.println("No numbers entered");
}
```


More operators

- Increment operator:
  `sum += number;`
  instead of:
  `sum = sum + number;`
- Also: `-=` , `*=`, `/=`, `%=`
- Increment operator:
  `count++;`
  instead of :
  `count += 1;`
  `count = count + 1;`
- Also: `--`

do…while Repetition Structure

- Used (same as the while loop) when the number of repetitions is not known but…
- Because the check of the condition takes place at the end, the do…while is always executed **at least once**
- General syntax:

```
do {
   <body_of_statements>
}
while (condition);
```

- What does the code on the right do?

```
int number = 1;
int doubleNumber;
do {
   doubleNumber = 2 * number;
   System.out.println(doubleNumber);
   number++;
}
while(number <= 10 );
```


do...while Example

- Find the first power of 2 that is greater than 1000
  - (same exercise as Example 1 of the while loop)

```
int product = 1;

do {
   product = product * 2;
}
while(product <= 1000);

System.out.println(product);
```

Loop Control: `break`

- Used inside a loop in cases when after checking a condition we are certain that there is no reason to execute the following/remaining iterations
- Program execution continues after the end of the loop

`break` Example

[what does the following program do?]

```
public class BreakDemo {
    public static void main(String args[]) {
        String searchMe = "123ioanna22900%^(*$236";
        char searchFor = '9';
        boolean foundIt = false; //boolean flag

        for ( int i = 0; i < searchMe.length(); i++ ) {
            if (searchMe.charAt(i) == searchFor)               {
                foundIt = true;
                //if you find it once, there is no need to continue
                //looking to the rest of the string: BREAK the loop
                break;
            }
        }
        if (foundIt)
            System.out.println(searchFor + " appears in the string");
        else
            System.out.println(searchFor + " does not appear in the string");
    }
}
```

Loop Control: `continue`

- Used inside a loop in cases when after checking a condition we are certain that there is no reason to continue with the execution of the current iteration but want to move to the next iteration

`continue` Example

[what does the following program do?]

```
public class ContinueDemo {
  public static void main(String args[]) {
    String searchMe = "peter piper picked a peck of pickled peppers";
    int numberOfPs = 0;

    for (int i = 0; i < searchMe.length(); i++) {
      //interested only in p's
      if (searchMe.charAt(i) != 'p') {
        //if the letter is not a 'p' there is nothing to do
        //CONTINUE with the next letter
        continue;
      }
      //this is not executed when the letter is not a 'p' because
      //of the continue command
      numberOfPs++;
    }
    System.out.println("Found " + numberOfPs + " p's in the string" + searchMe);
  }
}
```

The previous program without the use of a **continue**

```
public class NonContinueDemo {
  public static void main(String args[]) {
    String searchMe = "peter piper picked a peck of pickled peppers";
    int numberOfPs = 0;

    for (int i = 0; i < searchMe.length(); i++) {
      //interested only in p's
      if (searchMe.charAt(i) == 'p')
        numberOfPs++;
      }
    }
    System.out.println("Found " + numberOfPs + " p's in the string" + searchMe);
  }
}
```


Check list

- What is a sentinel-controlled loop?
- Can 0 always be used as a sentinel value?
- What problems can you identify in the pieces of code to the right?

```
int counter;
int sum = 0 ;

while ( counter <= 1000 ) {
   sum = sum + counter ;
   counter = counter + 1 ;
}
```

```
int counter = 1 ;
int sum = 0;

while ( counter <= 1000 ) {
   sum = sum + counter ;
   counter = counter - 1 ;
}
```

```
int sum;
int counter = 1 ;

while ( counter <= 1000 ) {
   sum = sum + counter ;
   counter = counter + 1 ;
}
```

Check list (cont'd)

- What is the difference between a while and a do…while loop?
- How can I stop the execution of a repetition structure?
- How can I skip part of an iteration and move on to the next one?