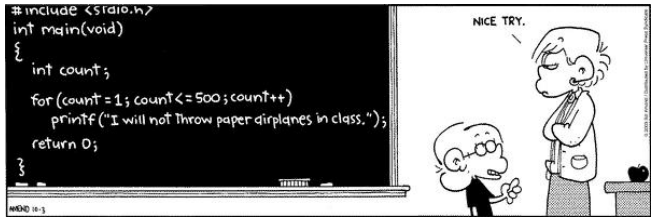
CS160

Flow of Control: Loops (Savitch, Chapter 4)

TOPICS

- while Loops
- do while Loops
- for Loops
- break Statement
- continue Statement

Loops!



An Example *while Loop*

```
int count = 1;
int sum = 0;
while (count < 5)
{
      sum += count;
      count++;
}
```

What exactly does this code do?

Step-by-step

```
int count = 1;
int sum = 0;
while (count < 5)
{
      sum += count;
      count++;
}
```

Code begins

count = 1, sum = 0

Test again (count < 5)

Bottom of loop: count = 2, sum = 1

More formally: *while* Loops

```
while (condition)
    body
```

- Repeatedly executes as long as the *condition* evaluates to `true`
- *body* of the loop is a single statement or multiple statements within { }
- The condition is tested before the body is executed, so loop may execute zero times
  - This is called a *pre-test* loop

Echo Example Program

```
import java.util.Scanner;

public class Foo {
   public static void main(String[] args) {
      Scanner in_str = new Scanner(System.in);
      String user_string = in_str.next();
      while (!user_string.equals("quit")) {
         System.out.println(user_string);
         user_string = in_str.next();
      }
   }
}
```


Echo Example: Notes

- "`import java.util.Scanner;`" is necessary to use a Scanner.
  - Problem: Without it, Eclipse will tell you it cannot resolve the Scanner class.
  - Solution: ctrl-shift-o will import needed classes.
- Remember that "!" means "not" in Java.
- Note the indentation: the body of the while loop is indented relative to the surrounding code.

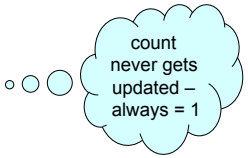
Echo Example: Questions

- How many times will the loop body execute?
  - Undetermined: it will keep executing until the user types "quit"
- What is the fewest number of times the loop body could execute?
  - Zero

Warning!

- An infinite loop will occur if the condition never becomes false.
- Example:

```
int count = 1;
int sum = 0;
while (count <= 5)
{
      sum += count;
}
```



What if my program gets caught in an infinite loop?

- You will need to kill your program
  - This is operating system specific
- Make your life easier: run your program in the debugger!
  - In Eclipse, select "debug" instead of "run".
  - It will offer to take you to the debug view.
  - Use the red button to kill the program.
  - Benefit: Run program step-by-step (F5).

Another example: find divisors

```
public class foo {
  public static void main(String[] args) {
    int number = Integer.parseInt(args[0]);
    int divisor = 2;
    while (divisor < number ) {
      if ((number % divisor) == 0) {
        System.out.print(divisor + " ");
      }
      divisor = divisor + 1;
    }
  }
}
```


Notes on divisor example (1)

- The main method takes an array of strings (called arguments or args).
  - args[0] is the first string passed to the method
  - args[1] would be the second string
  - args.length tells you how many strings there are
  - More about arrays later…

Notes on divisor example (2)

- Integer is an object class in Java. It has a method that reads a string and returns the integer it contains. Hence
  `Integer.parseInt(args[0]);`
- We append a space to the number when printing, so that the numbers are separated in the output.

Divisor example questions

- If the argument is '32', how many times will the loop body be executed?
  - 30
- If the argument is '2', how many times will the loop body be executed?
  - 0
- If the argument is '-5', what will happen?
  - The loop body will run 0 times

Example Program to Remove Vowels

```
public class Foo {
  public static void main(String[] args) {
    String str = args[0];
    int ctr = 0;
    while (ctr < str.length()) {
      switch(str.charAt(ctr)) {
        case 'a' :
        case 'e' :
        case 'i' :
        case 'o' :
        case 'u' : break;
        default : System.out.print(str.charAt(ctr));
      }
      ctr = ctr + 1;
    }
  ...
```


Remove Vowels: Notes

- The charAt(i) method of String returns the ith character.
  - Zero-based: 0, 1, 2, …
- The length() method of String returns the number of characters in the string.

Remove Vowels: Questions

- If the input is "Programming":
  - How many times will the loop body execute?
    - 11
  - What will the output be?
    - Prgrmmng
- If the input is "Java":
  - How many times will the loop body execute?
    - Exercise
  - What will the output be?
    - Exercise

for Loop

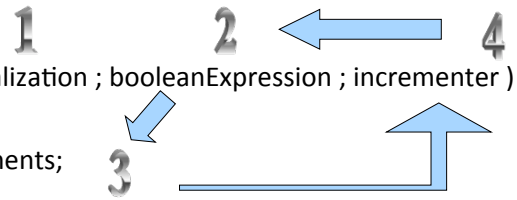
- It is common to iterate *counter* number of times.
  - *counter* might be a numeric bound
    - As in the divisor example
  - *counter* might be the length of a string or array
    - As in the remove vowels example
- A *for loop* gives you a mechanism to specify this explicitly

for Loop: Syntax

```
for (initialization; condition; update)
   body
```

- A pre-test loop that:
  - Initializes a loop variable
  - Executes body of loop zero or more times
  - Repeatedly:
    - Tests the condition
    - Executes the body if condition is true, else exits loop
    - Updates the loop variable

for Loop: Order



Example

```
int sum = 0;
for(int count=1; count <= 5; count++)
   sum +=count;
```


Mapping between `for` and `while`

- while loop version

```
initialization;
while (condition)
{
     statement;
     update;
}
```

- for loop version

```
for (initialization; condition; update )
    statement;
```


Temperature Conversion Program

```
System.out.println("\tDEGREES C\tDEGREES F");


for (int cent = 50; cent <= 100; cent++)
{
  double fahr = (9.0 / 5.0) * cent + 32.0;
  System.out.print("\t" + cent);
  System.out.println("\t" + fahr);
}
```

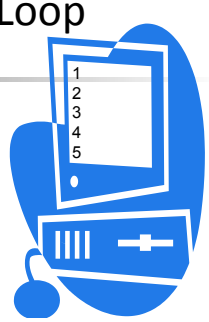

Example: Reversing a String

```
String s = "nice string";
for (int i=s.length()-1; i>= 0; i--)
{
  System.out.print(s.charAt(i));
}
```

Why the -1?

What happens if we use println instead of print?

Variants on the `for` Loop



- Multiple variables in `for` loop

```
int x = 1;
for( int lo = 0, hi = 10; lo < hi; lo++, hi--)
    System.out.println( x++ );
```

- Not all parts to the `for` loop

```
String s = "Javarules";
int i = s.length( ) – 1;
for ( ; i>=0;  )
  System.out.print( s.charAt(i--) );
```

do while Statement

```
do
{
   body
} while (condition);
```

- post-test loop: always executes the loop body at least once
- Executes again as long as its condition is true
- { } are required
- ; required after while

Example

```
int count = 1;
int sum = 0;
do
{
  sum += count;
  count++;
} while (count <= 5);
```

How does this differ from the previous?

Mapping between `do while` and `while`

- do while version

```
do
    statement;
while (condition);
```

- while version

```
statement;
while (condition)
    statement;
```

Which loop to use?

if (you know the # of iterations)
- use a **for** loop

else if (statements should be done at least once)
- use a **do…while** loop

else
- use a **while** loop

Problem Solving and Formulating Loops

- Stepwise Development:
  - Break problem into subparts
  - Identify repeating pattern in problem formulation
  - Put pattern into body of loop
  - Identify a continuing condition (or termination condition) that concerns what is being updated in the body of the loop
  - Make separate loops when multiple patterns are found; make nested loops when one pattern fits within another.

Example: Reading Input from User

- Strategy:
  - Ask user for input
  - Do something with the input
  - Ask user for input
  - Do something with the input
  - …
  - Until user no longer has input to enter
- Questions:
  - How does user indicate no more input?
  - What is the pattern?
  - What is terminating condition?

Reading Input Using a Loop

```
Scanner in = new Scanner( System.in );
int score = 0, sumOfScores = 0;
do {
    sumOfScores += score;
    System.out.println("Enter score [or -1 for end of input]: ");
    score = in.nextInt( );
} while( score != -1 );
System.out.println("Sum of scores was " + sumOfScores);
```

sentinel

pattern

When the user is entering a set of data, you need some way for them to say "no more" -- called a *sentinel*.

In other words …

- Stepwise refinement
  - don't do everything at once
  - identify sub-tasks and work on one at the time
- Identify loop patterns
  - the repeated behavior
  - what is to be done before the loop
    - e.g., initialization
  - how is loop termination decided
  - what needs to be done after the loop
    - e.g., store or print results

Nested Loops

- Write the code to print out the following:

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

ALGORITHM
OUTER LOOP: 10 times (10 rows)
  INNER LOOP: 1 to outer loop counter
    print *
  go to next line

Nested Loops

```
public class Stars
{
   public static void main(String[] args)
   {
       for( int c = 1; c <=10; c++ )
       {
             for( int i=0; i<c; i++ )
                   System.out.print( '*' );
             System.out.println( );
       }
   }
}
```

Why do we have an empty println ?

Cautions about Loops

- Ensure that the required precision of your condition matches that of the type (recall that two doubles may be *mathematically* equal but not in the computer!)
- Use { } for multiple statements
- Check for off-by-1 errors (make sure that it is ending at the right time)
- Do NOT put a ; at the end of a for( ) or while( ) !!!
- In a `while` loop, the condition must be testable prior to executing the body
- In any loop, ensure that the update will eventually cause variable(s) in the condition to cause the condition to become false.

Cautions about Loops

- Check for off-by-1 errors (make sure that it is ending at the right time)

```
for ( int i=1; i<100; i++ )
 {
   System.out.print( "*" );
 }
```

Prints 99 stars. Why?

Cautions about Loops

- Do NOT put a ; at the end of a for( ) or while( ) !!! Declares an empty body for the loop. Therefore the statements you think are in the body of the loop actually aren't

```
for ( int i=0; i<100; i++ );
 {
   System.out.print( "*" );
 }
```

Prints ONE star! Why?

Infinite Loop

- **Infinite Loops:** loop with a conditional that never becomes false:

```
while( true )
   computeSquares();
```

```
for (int i=1; i>0; i++ )
   processOutput( );
```

```
x = 1;
while( x < 10 );
   x = x + 5;
```

```
y = 1;
while( y < 10 )
   System.out.print( y );
   y++;
```


Programming Practice

- Run your loops by hand (pencil and paper)
  - Write out expectations, check them if need be
- Don't use `break` and `continue` in loops
  - They get very confusing very fast
- Echo values of variables

```
System.out.println("Str: " + Str);
```

- Use useful identifiers
  - no one-letter identifiers, except `for` loop indices
- Declare variables in the right scope
  - Often at top of scope is good
- Give yourself a chance to succeed
  - Don't start your project on day before the deadline

Loop Practice Problems

- Find the minimum integer in a sequence of integers
- Find the maximum in a sequence of integers
- Find the longest word in a sequence of words
- Determine if a word is a palindrome