Controlling Program Flow

The objectives of this lesson are:

- To explain boolean expressions
- To describe controlling program flow using *if* and *switch* statements
- To explain the three Java looping mechanisms
  - for
  - while
  - do while

Boolean Expressions

- Boolean expressions are those expressions which return either true or false.

- The return type of a boolean expression is boolean.
  - some other programming languages represent the return value of boolean expressions as integral values.

- Boolean expressions use the relational and equality operators as well as logical AND and OR.
  - >, >=, <, <=
  - !=, ==
  - &&, ||

- Boolean expressions can be used to control program flow.

Truth Tables

- Boolean algebra is based on Truth Tables
  - For A and B, both A and B must be true for the expression to evaluate to true.
  - For A or B, either A or B can be true and the expression will evaluate to true.

AND

B \ A	false	true
false	false	false
true	false	true

OR

B \ A	false	true
false	false	true
true	true	true

Truth Tables

- Java also has an operator for logical NOT (!).
  - Use parentheses to aid readability

```
if ((x == 5) && !(y > 50))
   statement1;
```

NOT

A	
false	true
true	false

Expression "Short Circuiting"

- Boolean expressions are "Short Circuited"
- Because of the nature of the truth table for AND, if any of the operands are false, the whole expression evaluates to false.
  - Sub expressions need not be evaluated
- A similar case exists with OR. If any of the operands are true, the whole expression evaluates to true.
- In this example, if x is not equal to 5 the second expression (y>50) will not be evaluated because the first operand to && is false.

```
if ((x == 5) && (y > 50))
   statement1;
```

Tips for Boolean Expressions

- One of the most common mistakes is using the assignment operator instead of testing equality.

mistake:

```
if (x = 5)
   statement1;
```

instead of

```
if (x == 5)
   statement1;
```

- Although logical AND (&&) has a higher precedence than logical OR (||), it is a good idea to use parentheses to aid readability.

```
if ( ((x == 5) && (y > 50)) || (x>50))
   statement1;
```

If statements

- The general form is:

```
if (boolean-expression)
   statement1;
else
   statement2;
```

- If the boolean expression evaluates to true, statement1 is executed. If false, statement2 is executed.
- The else clause is optional.
- If more than one statement is to be executed, the statements must be grouped in a block.

If statements using blocks

- When executing multiple statements:

```
if (boolean-expression)
{
   statement1;
   statement2;
   statement3;
}
else
{
   statement4;
   statement5;
   statement6;
}
```

- Statement indentation and placement of curly braces should enhance readability.

Nested if statements

- If statements can be nested. When doing so, it is recommended that curly braces and indentation be used to clearly show the structure of the code.

```
if (boolean-expression)
{
    if (boolean-expression)
    {
            statement1;
    }
    else
    {
            statement2;
    }
}
else
{
    statement3;
}
```

Ternary Operator -- ?:

- The ternary operator is a shortcut for the following code:

```
if (boolean-expression)
   result = value1;
else
   result = value2;
```

general syntax:

```
(boolean-expression)? value1 : value2
```

- If the boolean expression evaluates true, the whole expression evaluates to value1. Otherwise, it is value2.

```
z = (x > y)? x : y;
```

is equivalent to:

```
if (x > y)
   z = x;
else
   z = y;
```

Switch Statement

- Sometimes, using if-else statements can become unruly:

```
if (x == 1)
   statement1;
else if (x == 2)
   statement2;
else if (x == 3)
   statement3;
else if (x == 4)
   statement4;

[ ... ]
```

- Code structures like this are difficult to read and maintain.
- The switch statement is a better choice.

Switch Statement

- General Syntax:

```
switch( integer_expression )
{
   case constant1:

          statement1;
                                  break;
   case constant2:

          statement2;
                                  break;
   case constant3:

          statement3;
                                  break;
   default:
                    statement4;
}
```

- The integer expression is evaluated
- Control passes to the case whose integer constant matches the value of the expression.
- If there is no match, control passes to the default case. If no default case is present, control leaves the switch statement.

Notes on the Switch statement

- The condition is an integer value.
- The case value must be known at compile time. It is good coding practice to use final variables as case constants.
- The default case is optional.
- The break statement causes execution to leave the switch statement. If the break statement is not present, execution will continue to the next statement, even if it is within another case.

Loops

- Loops are used to execute statements or blocks multiple times based on a looping condition.
- Java has three types of loops:
  - while loops
  - do while loops
  - for loops
- Care should be taken whenever a loop is used to avoid an endless loop.

while loops

- The while loop is the most basic loop in Java.

```
while (boolean-expression)
{
   statement1;
   [...]
}
```

- The loop body will continue to execute as long as the looping condition is true. The looping condition is tested upon entry and when the loop body is completed.
- If the loop body consists of a single statement, the curly braces are not necessary.
- If the looping condition is false upon entry, the loop body will not be executed.

do while loops

- The do-while loop is identical to the while loop except that the test is evaluated at the end of the loop.

```
do
{
   statement1;
   [...]
} while (boolean-expression);
```

- Because the looping condition is evaluated at the end of the loop body, the loop body is guaranteed to execute at least once.

Loops - Examples

- What will these loops output?

```
int x = 0;
while(x<10)
{
   System.out.println(x++);
}
```

```
int x = 0;
while(x<10)
{
   System.out.println(++x);
}
```

```
int x = 0;
do
{
   System.out.println(x);
   x = x+1;
} while(x<10);
```

Loops - Common Errors

- What are the errors in these loops?

endless loop

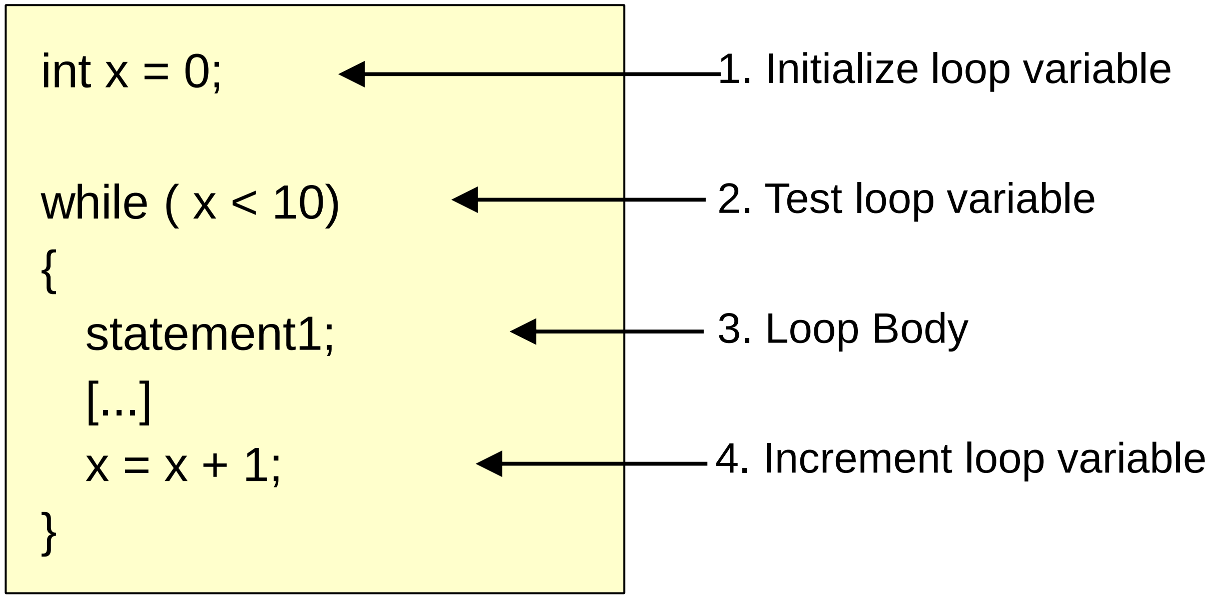
```
int x = 0;
while(x<10);
{
   System.out.println(x++);
}
```

endless loop

```
int x = 0;
do
{
   System.out.println(x);
} while(x<10);
```

Loop Components

- Each loop has 4 main components



```
int x = 0;

while ( x < 10)
{
   statement1;
   [...]
   x = x + 1;
}
```

for loop

- The syntax of the for loop makes the 4 parts of the loop explicit.

```
int x = 0;

while ( x < 10)
{
   statement1;
   [...]
   x = x + 1;
}
```

1. Initialize loop variable
2. Test loop variable
3. Loop Body
4. Increment loop variable

syntax:

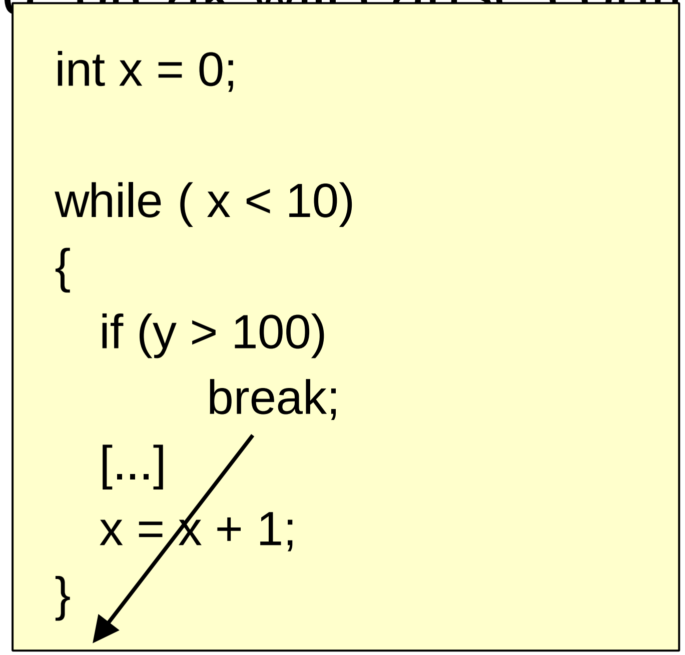
```
for (i = 0; i < 10; i++)
{
   statement1;
   [...]
}
```

Notes about loops

- The test condition on the for loop is the same as the while loop. The loop body is executed while the condition is true.
- The initialization and increment portions of the for loop are optional. However, the semicolons must be present.
- If the test condition is omitted, the test is always true.
- for loops are generally used when the number of times the loop is to be executed is known.
  - Do not adjust the looping variable within the loop
- while and do-while loops are used when the number of times the loop is to be executed is not known.
  - The focus is "while" this condition is true.

break revisited

- We previously saw the break statement used in switch statements.
  - break can also be used with loops.
- The break statement will cause the flow of execution to break out of the current loop.
- If loops are nested, break will cause control to leave the inner-most loop.



```
int x = 0;

while ( x < 10)
{
   if (y > 100)
          break;
   [...]
   x = x + 1;
}
```

continue

- continue is similar to break.
- continue causes execution to go back to the loop test condition. If the test condition is true, the loop will be executed again. If not, the loop body is exited.

```
int x = 0;

while ( x < 10)
{
   if (y > 100)
            continue;
   [...]
   x = x + 1;
}
```

Notes about break and continue

- Do not overuse break and continue.
- break and continue are structured goto statements.
  - The overuse of break and continue usually indicates a poor design.
  - Re-design and re-write is usually the best solution.
- Overuse of if and switch statements generally indicates a procedural solution.
  - Refactoring is often a good solution

    (Refactoring: Improving the design of existing code
    by Martin Fowler
    Addison-Wesley, 2000
    ISBN: 0201485672)

Review

- What are boolean expressions?
- How are boolean expressions used to change program flow?
- What is short circuiting? Why is it important?
- What is the general form of an if statement?
- What is the purpose of the switch statement?
- Name the three types of loops in Java
- How are while and do while loops different?
- What do the break and continue statements do?