Chapter 3: Program Statements

Presentation slides for

Java Software Solutions

for AP* Computer Science

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Program Statements

- Now we will examine some other program statements

- Chapter 3 focuses on:
  - program development stages
  - the flow of control through a method
  - decision-making statements
  - expressions for making complex decisions
  - repetition statements
  - drawing with conditionals and loops

Program Development

- The creation of software involves four basic activities:
  - establishing the requirements
  - creating a design
  - implementing the code
  - testing the implementation
- The development process is much more involved than this, but these are the four basic development activities

Requirements

- *Software requirements* specify the tasks a program must accomplish (what to do, not how to do it)
- They often include a description of the user interface
- An initial set of requirements often are provided, but usually must be critiqued, modified, and expanded
- Often it is difficult to establish detailed, unambiguous, complete requirements
- Careful attention to the requirements can save significant time and expense in the overall project

Design

- A *software design* specifies how a program will accomplish its requirements
- A design includes one or more *algorithms* to accomplish its goal
- An *algorithm* is a step-by-step process for solving a problem
- An algorithm may be expressed in *pseudocode*, which is code-like, but does not necessarily follow any specific syntax
- In object-oriented development, the design establishes the classes, objects, methods, and data that are required

Implementation

- *Implementation* is the process of translating a design into source code
- Most novice programmers think that writing code is the heart of software development, but actually it should be the least creative step
- Almost all important decisions are made during requirements and design stages
- Implementation should focus on coding details, including style guidelines and documentation

Testing

- A program should be executed multiple times with various input in an attempt to find errors
- *Debugging* is the process of discovering the causes of problems and fixing them
- Programmers often think erroneously that there is "only one more bug" to fix
- Tests should consider design details as well as overall requirements

Flow of Control

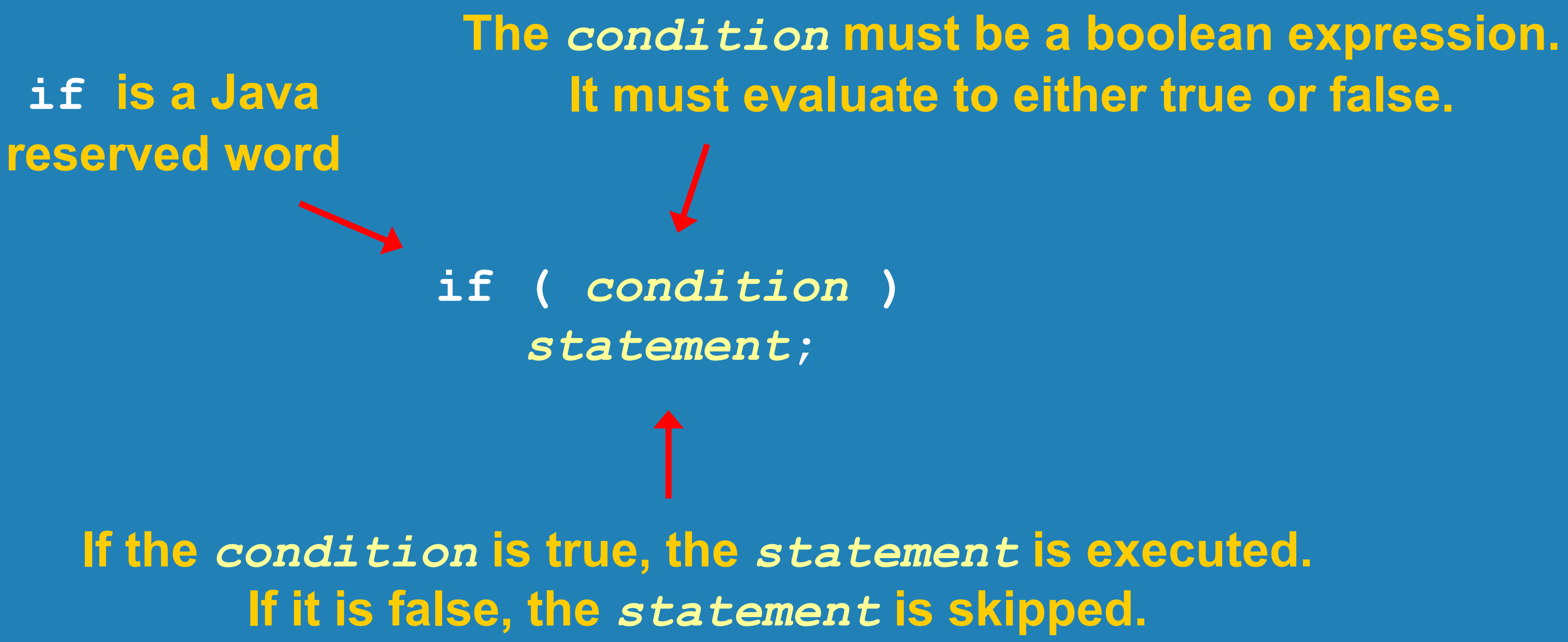
- Unless specified otherwise, the order of statement execution through a method is linear: one statement after the other in sequence
- Some programming statements modify that order, allowing us to:
  - decide whether or not to execute a particular statement, or
  - perform a statement over and over, repetitively
- These decisions are based on a *boolean expression* (also called a *condition*) that evaluates to true or false
- The order of statement execution is called the *flow of control*

Conditional Statements

- A *conditional statement* lets us choose which statement will be executed next
- Therefore they are sometimes called *selection statements*
- Conditional statements give us the power to make basic decisions
- Some conditional statements in Java are
  - the *if statement*
  - the *if-else statement*

The if Statement

- The *if statement* has the following syntax:



The *condition* must be a boolean expression. It must evaluate to either true or false.

`if` is a Java reserved word

```
if ( condition )
   statement;
```

If the *condition* is true, the *statement* is executed. If it is false, the *statement* is skipped.

The if Statement

- An example of an `if` statement:

```
if (sum > MAX)
   delta = sum - MAX;
System.out.println ("The sum is " + sum);
```

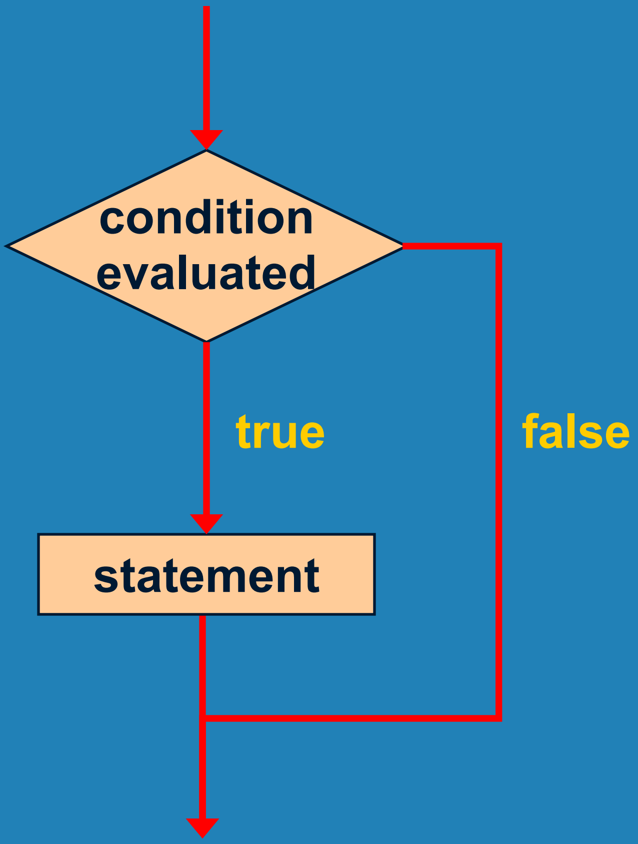
First, the condition is evaluated. The value of `sum` is either greater than the value of `MAX`, or it is not.

If the condition is true, the assignment statement is executed. If it is not, the assignment statement is skipped.

Either way, the call to `println` is executed next.

- See Age.java (page 126)

Logic of an if statement



Boolean Expressions

- A condition often uses one of Java's *equality operators* or *relational operators*, which all return boolean results:

`==`	equal to
`!=`	not equal to
`<`	less than
`>`	greater than
`<=`	less than or equal to
`>=`	greater than or equal to

- Note the difference between the equality operator (==) and the assignment operator (=)

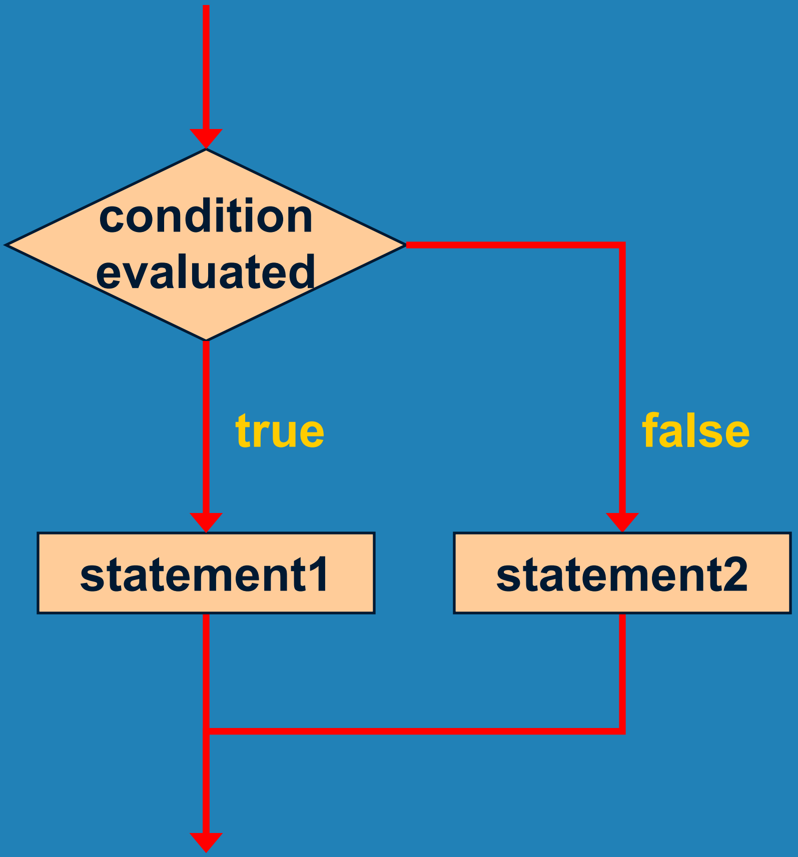
The if-else Statement

- An *else clause* can be added to an `if` statement to make an *if-else statement*

```
if ( condition )
   statement1;
else
   statement2;
```

- If the *`condition`* is true, *`statement1`* is executed; if the condition is false, *`statement2`* is executed
- One or the other will be executed, but not both
- See Wages.java (page 130)

Logic of an if-else statement



Block Statements

- Several statements can be grouped together into a *block statement*
- A block is delimited by braces : `{ … }`
- A block statement can be used wherever a statement is called for by the Java syntax
- For example, in an `if-else` statement, the `if` portion, or the `else` portion, or both, could be block statements
- See Guessing.java (page 132)

Nested if Statements

- The statement executed as a result of an `if` statement or `else` clause could be another `if` statement
- These are called *nested if statements*
- See MinOfThree.java (page 134)
- An `else` clause is matched to the last unmatched `if` (no matter what the indentation implies)
- Braces can be used to specify the `if` statement to which an `else` clause belongs

Logical Operators

- Boolean expressions can use the following *logical operators*:

`!`	Logical NOT
`&&`	Logical AND
`||`	Logical OR

- They all take boolean operands and produce boolean results
- Logical NOT is a unary operator (it operates on one operand)
- Logical AND and logical OR are binary operators (each operates on two operands)

Logical NOT

- The *logical NOT* operation is also called *logical negation* or *logical complement*
- If some boolean condition `a` is true, then `!a` is false; if `a` is false, then `!a` is true
- Logical expressions can be shown using *truth tables*

`a`	`!a`
true	false
false	true

Logical AND and Logical OR

- The *logical AND* expression

```
a && b
```

is true if both `a` and `b` are true, and false otherwise

- The *logical OR* expression

```
a || b
```

is true if `a` or `b` or both are true, and false otherwise

Truth Tables

- A truth table shows the possible true/false combinations of the terms
- Since `&&` and `||` each have two operands, there are four possible combinations of conditions `a` and `b`

`a`	`b`	`a && b`	`a || b`
true	true	true	true
true	false	false	true
false	true	false	true
false	false	false	false

Logical Operators

- Conditions can use logical operators to form complex expressions

```
if (total < MAX+5 && !found)
   System.out.println ("Processing…");
```

- Logical operators have precedence relationships among themselves and with other operators
  - all logical operators have lower precedence than the relational or arithmetic operators
  - logical NOT has higher precedence than logical AND and logical OR

Short Circuited Operators

- The processing of logical AND and logical OR is "short-circuited"
- If the left operand is sufficient to determine the result, the right operand is not evaluated

```
if (count != 0 && total/count > MAX)
    System.out.println ("Testing…");
```

- This type of processing must be used carefully

Truth Tables

- Specific expressions can be evaluated using truth tables

`total < MAX`	`found`	`!found`	`total < MAX && !found`
false	false	true	false
false	true	false	false
true	false	true	true
true	true	false	false

Comparing Characters

- We can use the relational operators on character data
- The results are based on the Unicode character set
- The following condition is true because the character `+` comes before the character `J` in the Unicode character set:

```
if ('+' < 'J')
   System.out.println ("+ is less than J");
```

- The uppercase alphabet (A-Z) followed by the lowercase alphabet (a-z) appear in alphabetical order in the Unicode character set

Comparing Strings

- Remember that a character string in Java is an object
- We cannot use the relational operators to compare strings
- The `equals` method can be called with strings to determine if two strings contain exactly the same characters in the same order
- The `String` class also contains a method called `compareTo` to determine if one string comes before another (based on the Unicode character set)

Lexicographic Ordering

- Because comparing characters and strings is based on a character set, it is called a *lexicographic ordering*
- This is not strictly alphabetical when uppercase and lowercase characters are mixed
- For example, the string `"Great"` comes before the string `"fantastic"` because all of the uppercase letters come before all of the lowercase letters in Unicode
- Also, short strings come before longer strings with the same prefix (lexicographically)
- Therefore `"book"` comes before `"bookcase"`

Comparing Float Values

- We also have to be careful when comparing two floating point values (`float` or `double`) for equality
- You should rarely use the equality operator (==) when comparing two floats
- In many situations, you might consider two floating point numbers to be "close enough" even if they aren't exactly equal
- Therefore, to determine the equality of two floats, you may want to use the following technique:

```
if (Math.abs(f1 - f2) < 0.00001)
   System.out.println ("Essentially equal.");
```

More Operators

- To round out our knowledge of Java operators, let's examine a few more

- In particular, we will examine
  - the increment and decrement operators
  - the assignment operators

Increment and Decrement

- The increment and decrement operators are arithmetic and operate on one operand
- The *increment operator* (`++`) adds one to its operand
- The *decrement operator* (`--`) subtracts one from its operand
- The statement

```
count++;
```

is functionally equivalent to

```
count = count + 1;
```

Assignment Operators

- Often we perform an operation on a variable, and then store the result back into that variable
- Java provides *assignment operators* to simplify that process
- For example, the statement

```
num += count;
```

is equivalent to

```
num = num + count;
```

Assignment Operators

- There are many assignment operators, including the following:

Operator	Example	Equivalent To
`+=`	`x += y`	`x = x + y`
`-=`	`x -= y`	`x = x - y`
`*=`	`x *= y`	`x = x * y`
`/=`	`x /= y`	`x = x / y`
`%=`	`x %= y`	`x = x % y`

Assignment Operators

- The right hand side of an assignment operator can be a complex expression
- The entire right-hand expression is evaluated first, then the result is combined with the original variable
- Therefore

```
result /= (total-MIN) % num;
```

is equivalent to

```
result = result / ((total-MIN) % num);
```

Assignment Operators

- The behavior of some assignment operators depends on the types of the operands
- If the operands to the += operator are strings, the assignment operator performs string concatenation
- The behavior of an assignment operator (+=) is always consistent with the behavior of the "regular" operator (+)

Repetition Statements

- *Repetition statements* allow us to execute a statement multiple times
- Often they are referred to as *loops*
- Like conditional statements, they are controlled by boolean expressions
- The text covers two kinds of repetition statements:
  - the *while loop*
  - the *for loop*
- The programmer should choose the right kind of loop for the situation

The while Statement

- The *while statement* has the following syntax:

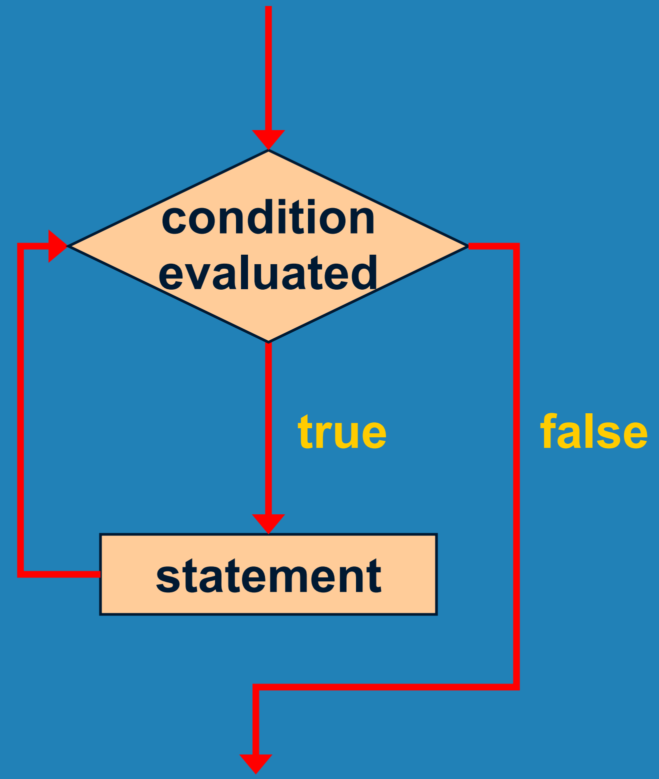
```
while ( condition )
   statement;
```

`while` is a reserved word

If the *`condition`* is true, the *`statement`* is executed. Then the *`condition`* is evaluated again.

The *`statement`* is executed repeatedly until the *`condition`* becomes false.

Logic of a while Loop



The while Statement

- Note that if the condition of a `while` statement is false initially, the statement is never executed
- Therefore, the body of a `while` loop will execute zero or more times
- See Counter.java (page 143)
- See Average.java (page 144)
  - A *sentinel value* indicates the end of the input
  - The variable `sum` maintains a *running sum*
- See WinPercentage.java (page 147)
  - A loop is used to *validate the input,* making the program more *robust*

Infinite Loops

- The body of a `while` loop eventually must make the condition false
- If not, it is an *infinite loop*, which will execute until the user interrupts the program
- This is a common logical error
- You should always double check to ensure that your loops will terminate normally
- See Forever.java (page 148)

Nested Loops

- Similar to nested `if` statements, loops can be nested as well
- That is, the body of a loop can contain another loop
- Each time through the outer loop, the inner loop goes through its full set of iterations
- See PalindromeTester.java (page 151)

The StringTokenizer Class

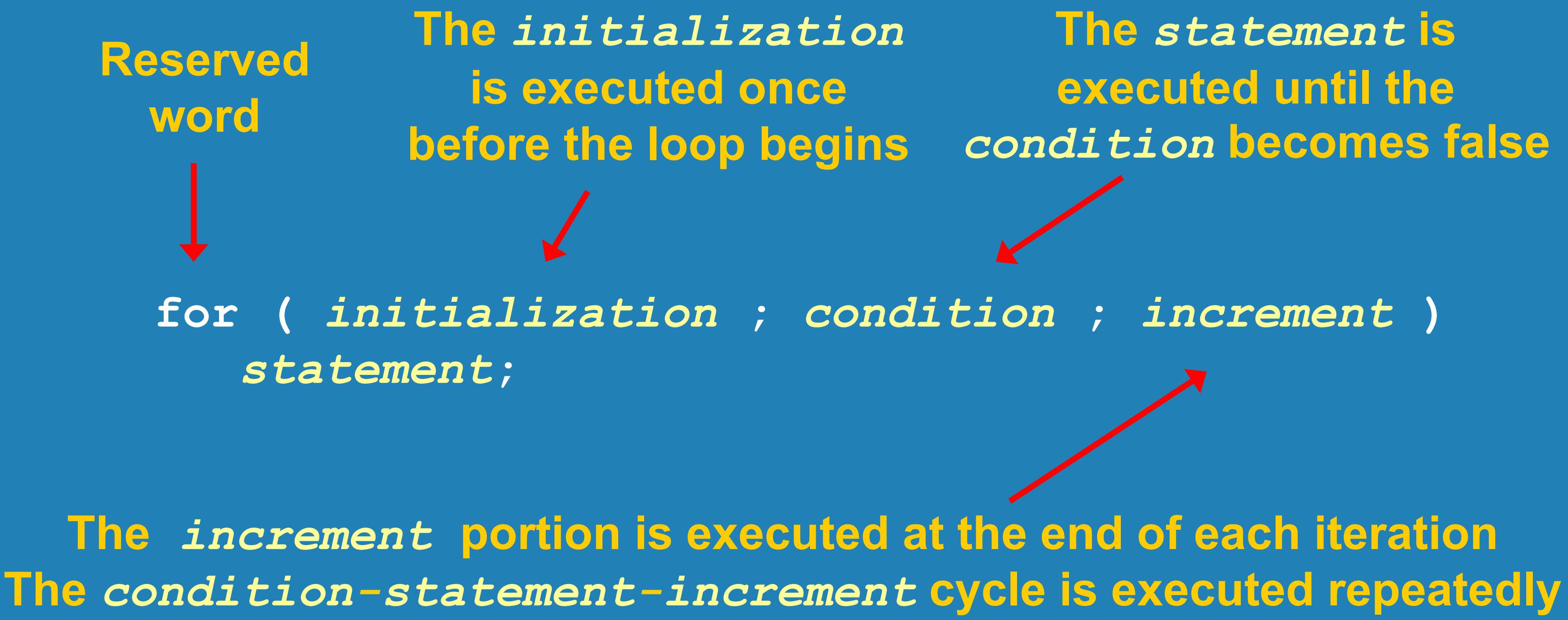
- The elements that comprise a string are referred to as *tokens*
- The process of extracting these elements is called *tokenizing*
- Characters that separate one token from another are called *delimiters*
- The `StringTokenizer` class, which is defined in the `java.util` package, is used to separate a string into tokens

The StringTokenizer Class

- The default delimiters are space, tab, carriage return, and the new line characters
- The `nextToken` method returns the next token (substring) from the string
- The `hasMoreTokens` returns a boolean indicating if there are more tokens to process
- See CountWords.java (page 155)

The for Statement

- The *for statement* has the following syntax:



Reserved word

The *initialization* is executed once before the loop begins

The *statement* is executed until the *condition* becomes false

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

The *increment* portion is executed at the end of each iteration

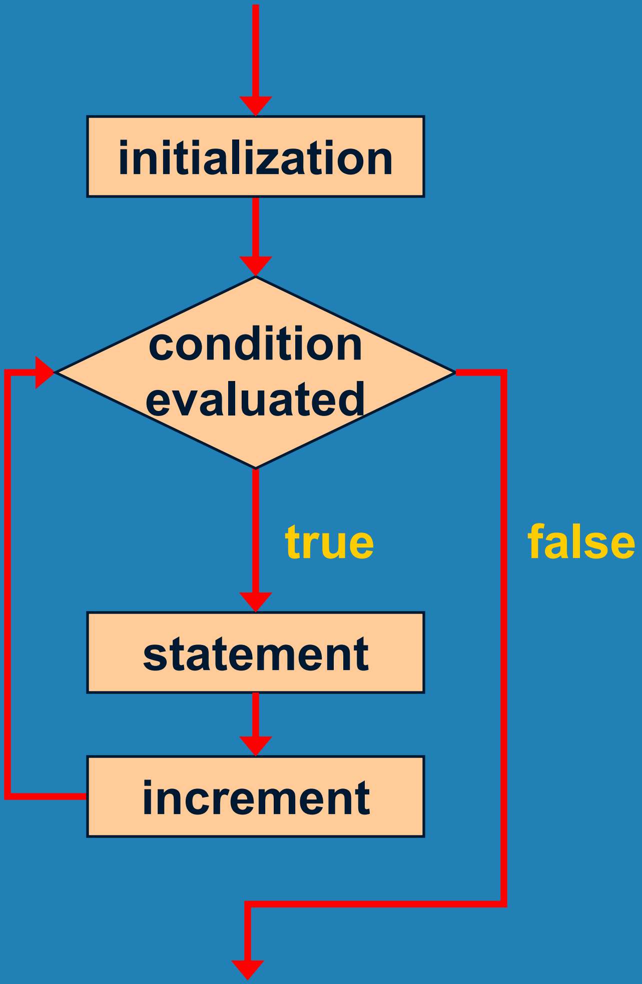
The *condition-statement-increment* cycle is executed repeatedly

The for Statement

- A `for` loop is functionally equivalent to the following `while` loop structure:

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

Logic of a for loop



The for Statement

- Like a `while` loop, the condition of a `for` statement is tested prior to executing the loop body
- Therefore, the body of a `for` loop will execute zero or more times
- It is well suited for executing a loop a specific number of times that can be determined in advance
- See Counter2.java (page 157)
- See Multiples.java (page 159)
- See Stars.java (page 161)

The for Statement

- Each expression in the header of a for loop is optional
  - If the *`initialization`* is left out, no initialization is performed
  - If the *`condition`* is left out, it is always considered to be true, and therefore creates an infinite loop
  - If the *`increment`* is left out, no increment operation is performed
- Both semi-colons are always required in the `for` loop header

Choosing a Loop Structure

- When you can’t determine how many times you want to execute the loop body, use a `while` statement

- If you can determine how many times you want to execute the loop body, use a `for` statement

Program Development

- We now have several additional statements and operators at our disposal
- Following proper development steps is important
- Suppose you were given some initial requirements:
  - accept a series of test scores
  - compute the average test score
  - determine the highest and lowest test scores
  - display the average, highest, and lowest test scores

Program Development

- Requirements Analysis – clarify and flesh out specific requirements
  - How much data will there be?
  - How should data be accepted?
  - Is there a specific output format required?
- After conferring with the client, we determine:
  - the program must process an arbitrary number of test scores
  - the program should accept input interactively
  - the average should be presented to two decimal places
- The process of requirements analysis may take a long time

Program Development

- Design – determine a possible general solution
  - Input strategy? (Sentinel value?)
  - Calculations needed?
- An initial algorithm might be expressed in pseudocode
- Multiple versions of the solution might be needed to refine it
- Alternatives to the solution should be carefully considered

Program Development

- Implementation – translate the design into source code
- Make sure to follow coding and style guidelines
- Implementation should be integrated with compiling and testing your solution
- This process mirrors a more complex development model we'll eventually need to develop more complex software
- The result is a final implementation
- See ExamGrades.java (page 164)

Program Development

- Testing – attempt to find errors that may exist in your programmed solution
- Compare your code to the design and resolve any discrepancies
- Determine test cases that will stress the limits and boundaries of your solution
- Carefully retest after finding and fixing an error

More Drawing Techniques

- Conditionals and loops can greatly enhance our ability to control graphics
- See Bullseye.java (page 169)
- See Boxes.java (page 171)
- See BarHeights.java (page 173)

Summary

- Chapter 3 has focused on:
  - program development stages
  - the flow of control through a method
  - decision-making statements
  - expressions for making complex decisions
  - repetition statements
  - drawing with conditionals and loops