Chapter 2

Writing Java Programs

2.1 A Simple Java Program

- The following program displays the message `Java rules!` on the screen.

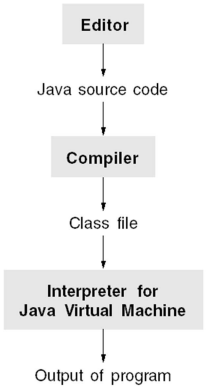
JavaRules.java

```
// Displays the message "Java rules!"

public class JavaRules {
  public static void main(String[] args) {
    System.out.println("Java rules!");
  }
}
```


2.2 Executing a Java Program

- Steps involved in executing a Java program:
  - Enter the program
  - Compile the program
  - Run the program
- With an integrated development environment, all three steps can be performed within the environment itself.



Integrated Development Environments

- An ***integrated development environment*** (IDE) is an integrated collection of software tools for developing and testing programs.
- A typical IDE includes at least an editor, a compiler, and a debugger.
- A programmer can write a program, compile it, and execute it, all without leaving the IDE.

Entering a Java Program

- Crimson editor is chosen as our editor. Using it, you can type, compile (using ctrl-1), and run (using ctrl-2) programs.
- Any editor or word processor can be also used to enter a program, including Notepad or WordPad.

Another Way to Compile a Java Program

- Before compiling a program under Windows, open a command window and use the `cd` (change directory) command to select the directory that contains the program:

```
cd c:\myfiles\java\programs
```

- To compile the program, use the `javac` command:

```
javac JavaRules.java
```

- The file name must match the program name, and the `.java` extension must be included.

Another Way to Run a Java Program

- If the compiler doesn't find any errors in the program, it creates a ***class file*** containing bytecode instructions. This file will have the same name as the program but with `.class` as the extension.
- To run a program, use the `java` command, which executes the Java interpreter.
- `java` requires that the name of a class file be specified (without the `.class` extension):

```
java JavaRules
```


2.3 Program Layout

- The `JavaRules` program raises a couple of issues:
  - Why do we put comments into programs, and what are the rules for doing so?
  - How should we "lay out" a program? Does it matter where we put spaces and blank lines? Where should the curly braces go?

Comments

- ***Comments*** are an important part of every program.
- They provide information that's useful for anyone who will need to read the program in the future.
- Typical uses of comments:
  - To document who wrote the program, when it was written, what changes have been made to it, and so on.
  - To describe the behavior or purpose of a particular part of the program, such as a variable or method.
  - To describe how a particular task was accomplished, which algorithms were used, or what tricks were employed to get the program to work.

Types of Comments

- Single-line comments:

```
// Comment style 1
```

- Multiline comments:

```
/* Comment style 2 */
```

- "Doc" comments:

```
/** Comment style 3 */
```

- Doc comments are designed to be extracted by a special program, `javadoc`.

Problems with Multiline Comments

- Forgetting to terminate a multiline comment may cause the compiler to ignore part of a program:

```
System.out.print("My ");   /* forgot to close this comment...
System.out.print("cat ");
System.out.print("has ");  /* so it ends here */
System.out.println("fleas");
```

Single-line Comments

- Many programmers prefer `//` comments to `/*` … `*/` comments, for several reasons:
  - Ease of use
  - Safety
  - Program readability
  - Ability to "comment out" portions of a program

Tokens

- A Java compiler groups the characters in a program into ***tokens.***
- The compiler then puts the tokens into larger groups (such as statements, methods, and classes).
- Tokens in the `JavaRules` program:

```
public class JavaRules { public static void main ( String [ ] args ) { System . out . println ( "Java rules!" ) ; } }
```


Avoiding Problems with Tokens

- Always leave at least one space between tokens that would otherwise merge together:
  `publicclassJavaRules {`
- Don't put part of a token on one line and the other part on the next line:

```
pub
lic class JavaRules {
```


Indentation

- Programmers use indentation to indicate nesting.
- An increase in the amount of indentation indicates an additional level of nesting.
- The `JavaRules` program consists of a statement nested inside a method nested inside a class:

```
public class JavaRules {
  public static void main(String[] args) {
    System.out.println("Java rules!");
  }
}
```


How Much Indentation?

- Common amounts of indentation:
  - 2 spaces: the bare minimum
  - 3 spaces: the optimal amount
  - 4 spaces: what many programmers use
  - 8 spaces: probably too much
- The `JavaRules` program with an indentation of four spaces:

```
public class JavaRules {
    public static void main(String[] args) {
        System.out.println("Java rules!");
    }
}
```


Brace Placement

- Brace placement is another important issue.
- One technique is to put each left curly brace at the end of a line. The matching right curly brace is lined up with the first character on that line:

```
public class JavaRules {
  public static void main(String[] args) {
    System.out.println("Java rules!");
  }
}
```

Brace Placement

- Some programmers prefer to put left curly braces on separate lines:

```
public class JavaRules
{
  public static void main(String[] args)
  {
    System.out.println("Java rules!");
  }
}
```

- This makes it easier to verify that left and right braces match up properly. However, program files become longer because of the additional lines.

Brace Placement

- To avoid extra lines, the line containing the left curly brace can be combined with the following line:

```
public class JavaRules
{ public static void main(String[] args)
  { System.out.println("Java rules!");
  }
}
```

- In a commercial environment, issues such as indentation and brace placement are often resolved by a "coding standard," which provides a uniform set of style rules for all programmers to follow.

2.4 Using Variables

- In Java, every variable must be ***declared*** before it can be used.
- Declaring a variable means informing the compiler of the variable's name and its properties, including its ***type.***
- `int` is one of Java's types. Variables of type `int` can store integers (whole numbers).

Declaring Variables

- Form of a ***variable declaration:***
  - The type of the variable
  - The name of the variable
  - A semicolon
- Example:

```
int i;  // Declares i to be an int variable
```

- Several variables can be declared at a time:

```
int i, j, k;
```

- It's often better to declare variables individually.

Initializing Variables

- A variable is given a value by using =, the ***assignment operator:***

```
i = 0;
```

- ***Initializing*** a variable means to assign a value to the variable for the first time.
- Variables always need to be initialized before the first time their value is used.
- The Java compiler checks that variables declared in methods are initialized prior to their first use.

Initializers

- Variables can be initialized at the time they're declared:

```
int i = 0;
```

`0` is said to be the ***initializer*** for `i`.

- If several variables are declared at the same time, each variable can have its own initializer:

```
int i = 0, j, k = 1;
```

Changing the Value of a Variable

- The assignment operator can be used both to initialize a variable and to change the value of the variable later in the program:

```
i = 1;  // Value of i is now 1
…
i = 2;  // Value of i is now 2
```


Program: Printing a Lottery Number

Lottery.java

```
// Displays the winning lottery number

public class Lottery {
  public static void main(String[] args) {
    int winningNumber = 973;
    System.out.print("The winning number ");
    System.out.print("in today's lottery is ");
    System.out.println(winningNumber);
  }
}
```


2.5 Types

- A partial list of Java types:
  `int` — An integer
  `double` — A floating-point number
  `boolean` — Either `true` or `false`
  `char` — A character
- Declarations of `double`, `boolean`, and `char` variables:

```
double x, y;
boolean b;
char ch;
```


Literals

- A ***literal*** is a token that represents a particular number or other value.
- Examples of `int` literals:

```
0  297  30303
```

- Examples of `double` literals:

```
48.0  48.  4.8e1  4.8e+1  .48e2  480e-1
```

- The only `boolean` literals are `true` and `false`.
- `char` literals are enclosed within single quotes:

```
'a'  'z'  'A'  'Z'  '0'  '9'  '%'  '.'  ' '
```


Using Literals as Initializers

- Literals are often used as initializers:

```
double x = 0.0, y = 1.0;
boolean b = true;
char ch = 'f';
```


2.6 Identifiers

- ***Identifiers*** (names chosen by the programmer) are subject to the following rules:
  - Identifiers may contain letters (both uppercase and lowercase), digits, and underscores (_).
  - Identifiers begin with a letter or underscore.
  - There's no limit on the length of an identifier.
  - Lowercase letters are not equivalent to uppercase letters. (A language in which the case of letters matters is said to be ***case-sensitive.***)

Multiword Identifiers

- When an identifier consists of multiple words, it's important to mark the boundaries between words.
- One way to break up long identifiers is to use underscores between words:
  `last_index_of`
- Another technique is to capitalize the first letter of each word after the first:
  `lastIndexOf`
  This technique is the one commonly used in Java.

Conventions

- A rule that we agree to follow, even though it's not required by the language, is said to be a ***convention.***
- A common Java convention is beginning a class name with an uppercase letter:
  `Color`
  `FontMetrics`
  `String`
- Names of variables and methods, by convention, never start with an uppercase letter.

Keywords

- The following ***keywords*** can't be used as identifiers because Java has already given them a meaning:

```
abstract   double       int          super
boolean    else         interface    switch
break      extends      long         synchronized
byte       final        native       this
case       finally      new          throw
catch      float        package      throws
char       for          private      transient
class      goto         protected    try
const      if           public       void
continue   implements   return       volatile
default    import       short        while
do         instanceof   static
```

- `null`, `true`, and `false` are also reserved.

2.7 Performing Calculations

- In general, the right side of an assignment can be an ***expression.***
- A literal is an expression, and so is a variable.
- More complicated expressions are built out of ***operators*** and ***operands.***
- In the expression `5 / 9`, the operands are `5` and `9`, and the operator is `/`.
- The operands in an expression can be variables, literals, or other expressions.

Operators

- Java's arithmetic operators:
  `+` Addition
  `-` Subtraction
  `*` Multiplication
  `/` Division
  `%` Remainder
- Examples:
  `6 + 2` ⇒ 8
  `6 - 2` ⇒ 4
  `6 * 2` ⇒ 12
  `6 / 2` ⇒ 3

Integer Division

- If the result of dividing two integers has a fractional part, Java throws it away (we say that it ***truncates*** the result).
- Examples:
  `1 / 2` ⇒ 0
  `5 / 3` ⇒ 1

`double` Operands

- `+`, `-`, `*`, and `/` accept `double` operands:
  `6.1 + 2.5` ⇒ 8.6
  `6.1 - 2.5` ⇒ 3.6
  `6.1 * 2.5` ⇒ 15.25
  `6.1 / 2.5` ⇒ 2.44
- `int` and `double` operands can be mixed:
  `6.1 + 2` ⇒ 8.1
  `6.1 - 2` ⇒ 4.1
  `6.1 * 2` ⇒ 12.2
  `6.1 / 2` ⇒ 3.05

Binary Operators

- The `+`, `-`, `*`, and `/` operators are said to be ***binary*** operators, because they require two operands.
- There's one other binary arithmetic operator: `%` (remainder).
- The `%` operator produces the remainder when the left operand is divided by the right operand:
  `13 % 3` ⇒ 1
- `%` is normally used with integer operands.
- It's a good idea to put a space before and after each binary operator.

Unary Operators

- Java also has two ***unary*** arithmetic operators:
  `+` Plus
  `-` Minus
- Unary operators require just one operand.
- The unary `+` and `-` operators are often used in conjunction with literals (`-3`, for example).

Round-Off Errors

- Calculations involving floating-point numbers can sometimes produce surprising results.
- If `d` is declared as follows, its value will be 0.0999999999999987 rather than 0.1:
  ```
  double d = 1.2 - 1.1;
  ```
- ***Round-off errors*** such as this occur because some numbers (1.2 and 1.1, for example) can't be stored in `double` form with complete accuracy.

Operator Precedence

- What's the value of `6 + 2 * 3`?
  - `(6 + 2) * 3`, which yields 24?
  - `6 + (2 * 3)`, which yields 12?
- Operator precedence resolves issues such as this.
- `*`, `/`, and `%` take precedence over `+` and `-`.
- Examples:
  `5 + 2 / 2` ⇒ `5 + (2 / 2)` ⇒ 6
  `8 * 3 - 5` ⇒ `(8 * 3) - 5` ⇒ 19
  `6 - 1 * 7` ⇒ `6 - (1 * 7)` ⇒ –1
  `9 / 4 + 6` ⇒ `(9 / 4) + 6` ⇒ 8
  `6 + 2 % 3` ⇒ `6 + (2 % 3)` ⇒ 8

Associativity

- Precedence rules are of no help when it comes to determining the value of `1 - 2 - 3`.
- Associativity rules come into play when precedence rules alone aren't enough.
- The binary `+`, `-`, `*`, `/`, and `%` operators are all left associative:
  `2 + 3 - 4` ⇒ `(2 + 3) - 4` ⇒ 1
  `2 * 3 / 4` ⇒ `(2 * 3) / 4` ⇒ 1

Parentheses in Expressions

- Parentheses can be used to override normal precedence and associativity rules.
- Parentheses in the expression `(6 + 2) * 3` force the addition to occur before the multiplication.
- It's often a good idea to use parentheses even when they're not strictly necessary:
  `(x * x) + (2 * x) - 1`
- However, don't use too many parentheses:
  `((x) * (x)) + ((2) * (x)) - (1)`

Assignment Operators

- The assignment operator (=) is used to save the result of a calculation in a variable:
  `area = height * width;`
- The type of the expression on the right side of an assignment must be appropriate for the type of the variable on the left side of the assignment.
- Assigning a `double` value to an `int` variable is not legal. Assigning an `int` value to a `double` variable is OK, however.

Using Assignment to Modify a Variable

- Assignments often use the old value of a variable as part of the expression that computes the new value.
- The following statement adds 1 to the variable `i`:
  `i = i + 1;`

Compound Assignment Operators

- The ***compound assignment operators*** make it easier to modify the value of a variable.
- A partial list of compound assignment operators:
  - `+=` Combines addition and assignment
  - `-=` Combines subtraction and assignment
  - `*=` Combines multiplication and assignment
  - `/=` Combines division and assignment
  - `%=` Combines remainder and assignment

Compound Assignment Operators

- Examples:

```
i += 2;  // Same as i = i + 2;
i -= 2;  // Same as i = i - 2;
i *= 2;  // Same as i = i * 2;
i /= 2;  // Same as i = i / 2;
i %= 2;  // Same as i = i % 2;
```


Program: Converting from Fahrenheit to Celsius

FtoC.java

```
// Converts a Fahrenheit temperature to Celsius

public class FtoC {
  public static void main(String[] args) {
    double fahrenheit = 98.6;
    double celsius = (fahrenheit - 32.0) * (5.0 / 9.0);
    System.out.print("Celsius equivalent: ");
    System.out.println(celsius);
  }
}
```

2.8 Constants

- A ***constant*** is a value that doesn't change during the execution of a program.
- Constants can be named by assigning them to variables:

```
double freezingPoint = 32.0;
double degreeRatio = 5.0 / 9.0;
```

- To prevent a constant from being changed, the word `final` can be added to its declaration:

```
final double freezingPoint = 32.0;
final double degreeRatio = 5.0 / 9.0;
```


Naming Constants

- The names of constants are often written entirely in uppercase letters, with underscores used to indicate boundaries between words:

```
final double FREEZING_POINT = 32.0;
final double DEGREE_RATIO = 5.0 / 9.0;
```


Adding Constants to the `FtoC` Program

`FtoC2.java`

```
// Converts a Fahrenheit temperature to Celsius

public class FtoC2 {
  public static void main(String[] args) {
    final double FREEZING_POINT = 32.0;
    final double DEGREE_RATIO = 5.0 / 9.0;
    double fahrenheit = 98.6;
    double celsius =
      (fahrenheit - FREEZING_POINT) * DEGREE_RATIO;
    System.out.print("Celsius equivalent: ");
    System.out.println(celsius);
  }
}
```


Advantages of Naming Constants

- Advantages of naming constants:
  - Programs are easier to read. The alternative is a program full of "magic numbers."
  - Programs are easier to modify.
  - Inconsistencies and typographical errors are less likely.
- Always create meaningful names for constants. There's no point in defining a constant whose name signifies its value:

```
final int TWELVE = 12;
```


2.9 Methods

- A ***method*** is a series of statements that can be executed as a unit.
- A method does nothing until it is activated, or ***called.***
- To call a method, we write the name of the method, followed by a pair of parentheses.
- The method's ***arguments*** (if any) go inside the parentheses.
- A call of the `println` method:

```
System.out.println("Java rules!");
```


Methods in the `Math` Class

- The `Math` class contains a number of methods for performing mathematical calculations.
- These methods are called by writing `Math.`*name*, where *name* is the name of the method.
- The methods in the `Math` class ***return*** a value when they have completed execution.

The **pow** and **sqrt** Methods

- The `pow` method raises a number to a power:
  `Math.pow(2.0, 3.0)` ⇒ 8.0
  `Math.pow(-2.0, 3.0)` ⇒ –8.0
  `Math.pow(2.0, -1.0)` ⇒ 0.5
- The `sqrt` method computes the square root of a number:
  `Math.sqrt(2.0)` ⇒ 1.4142135623730951
  `Math.sqrt(4.0)` ⇒ 2.0
- Both `pow` and `sqrt` return values of type `double`.

The **abs** and **max** Methods

- The `abs` method computes the absolute value of a number:
  `Math.abs(2.0)` ⇒ 2.0
  `Math.abs(-2.0)` ⇒ 2.0
  `Math.abs(2)` ⇒ 2
  `Math.abs(-2)` ⇒ 2
- The `max` method finds the larger of two numbers:
  `Math.max(3.0, 5.5)` ⇒ 5.5
  `Math.max(10.0, -2.0)` ⇒ 10.0
  `Math.max(12, -23)` ⇒ 12
  `Math.max(-5, -2)` ⇒ –2

The **min** Method

- The `min` method finds the smaller of two numbers:
  `Math.min(3.0, 5.5)` ⇒ 3.0
  `Math.min(10.0, -2.0)` ⇒ –2.0
  `Math.min(12, -23)` ⇒ –23
  `Math.min(-5, -2)` ⇒ –5
- The value returned by `abs`, `max`, and `min` depends on the type of the argument:
  - If the argument is an `int`, the methods return an `int`.
  - If the argument is a `double`, the methods return a `double`.

The **round** Method

- The `round` method rounds a `double` value to the nearest integer:
  `Math.round(4.1)` ⇒ 4
  `Math.round(4.5)` ⇒ 5
  `Math.round(4.9)` ⇒ 5
  `Math.round(5.5)` ⇒ 6
  `Math.round(-4.1)` ⇒ –4
  `Math.round(-4.5)` ⇒ –4
  `Math.round(-4.9)` ⇒ –5
  `Math.round(-5.5)` ⇒ –5
- `round` returns a `long` value rather than an `int` value.

Using the Result of a Method Call

- The value returned by a method can be saved in a variable for later use:

```
double y = Math.abs(x);
```

- Another option is to use the result returned by a method directly, without first saving it in a variable. For example, the statements

```
double y = Math.abs(x);
double z = Math.sqrt(y);
```

  can be combined into a single statement:

```
double z = Math.sqrt(Math.abs(x));
```


Using the Result of a Method Call

- Values returned by methods can also be used as operands in expressions.
- Example (finding the roots of a quadratic equation):

```
double root1 =
  (-b + Math.sqrt(b * b - 4 * a * c)) / (2 * a);
double root2 =
  (-b - Math.sqrt(b * b - 4 * a * c)) / (2 * a);
```

- Because the square root of $b^2 - 4ac$ is used twice, it would be more efficient to save it in a variable:

```
double discriminant = Math.sqrt(b * b - 4 * a * c);
double root1 = (-b + discriminant) / (2 * a);
double root2 = (-b - discriminant) / (2 * a);
```

Using the Result of a Method Call

- The value returned by a method can be printed without first being saved in a variable:
  `System.out.println(Math.sqrt(2.0));`

2.10 Input and Output

- Most programs require both input and output.
- ***Input*** is any information fed into the program from an outside source.
- ***Output*** is any data produced by the program and made available outside the program.

Displaying Output on the Screen

- Properties of `System.out.print` and `System.out.println`:
  - Can display any single value, regardless of type.
  - The argument can be any expression, including a variable, literal, or value returned by a method.
  - `println` always advances to the next line after displaying its argument; `print` does not.

Displaying a Blank Line

- One way to display a blank line is to leave the parentheses empty when calling `println`:

```
System.out.println("Hey Joe");
System.out.println();  // Write a blank line
```

- The other is to insert `\n` into a string that's being displayed by `print` or `println`:

```
System.out.println("A hop,\na skip,\n\nand a jump");
```

  Each occurrence of `\n` causes the output to begin on a new line.

Escape Sequences

- The backslash character combines with the character after it to form an ***escape sequence:*** a combination of characters that represents a single character.
- The backslash character followed by `n` forms `\n`, the ***new-line character.***
- Another common escape sequence is `\"`, which represents `"` (double quote):

```
System.out.println("He yelled \"Stop!\" and we stopped.");
```

- In order to print a backslash character as part of a string, the string will need to contain two backslash characters:

```
System.out.println("APL\\360");
```


Printing Multiple Items

- The `+` operator can be used to combine multiple items into a single string for printing purposes:

```
System.out.println("Celsius equivalent: " + celsius);
```

- At least one of the two operands for the `+` operator must be a string.

- `System.out.printf()`, just like `printf()` in C.

Obtaining Input from the User (New)

- import the `Scanner` class and create the scanner

```
import java.util.Scanner;
Scanner input = new Scanner(System.in);
```

- `System.out.print()` is used to ***prompt*** the user:

```
System.out.print("Enter Fahrenheit temperature: ");
```

- Next, the `input.nextDouble()` method is used to ***read*** the user's input of type `double`:

```
double temperature = input.nextDouble();
```

- To read an integer, use the method `nextInt()`
- To read a string, use the method `nextLine()`

Packages

- Java allows classes to be grouped into larger units known as ***packages.***
- The package that contains `SimpleIO` and `Convert` is named `jpb` (*Java Programming: From the Beginning*).
- Java comes with a large number of standard packages.

Import Declarations

- Accessing the classes that belong to a package is done by using an ***import declaration:***

  `import` *package-name* `. * ;`

- Import declarations go at the beginning of a program. A program that needs `SimpleIO` or `Convert` would begin with the line

```
import jpb.*;
```


Application Programming Interfaces

- The packages that come with Java belong to the Java ***Application Programming Interface*** (API).
- In general, an API consists of code that someone else has written but that we can use in our programs.
- Typically, an API allows an application programmer to access a lower level of software.
- In particular, an API often provides access to the capabilities of a particular operating system or windowing system.

Program: Converting from Fahrenheit to Celsius (by Kelvin) `FtoC3n.java`

```
// Converts a Fahrenheit temperature entered by the user to
// Celsius (New)

import java.util.Scanner;

public class FtoC3n {
  public static void main(String[] args) {
    final double FREEZING_POINT = 32.0;
    final double DEGREE_RATIO = 5.0 / 9.0;

    System.out.print("Enter Fahrenheit temperature: ");
    Scanner input = new Scanner(System.in);
    double fahrenheit = input.nextDouble();
    double celsius =
      (fahrenheit - FREEZING_POINT) * DEGREE_RATIO;
    System.out.println("Celsius equivalent: " + celsius);
  }
}
```


Program: Converting from Fahrenheit to Celsius (by King) `FtoC3.java`

```
// Converts a Fahrenheit temperature entered by the user to
// Celsius

import jpb.*;

public class FtoC3 {
  public static void main(String[] args) {
    final double FREEZING_POINT = 32.0;
    final double DEGREE_RATIO = 5.0 / 9.0;

    SimpleIO.prompt("Enter Fahrenheit temperature: ");
    String userInput = SimpleIO.readLine();
    double fahrenheit = Convert.toDouble(userInput);
    double celsius =
      (fahrenheit - FREEZING_POINT) * DEGREE_RATIO;
    System.out.println("Celsius equivalent: " + celsius);
  }
}
```

Differences in the programs

```
Replace
  import jpb.*;
by
  import java.util.Scanner;

Replace
  SimpleIO.prompt("Enter temperature: ");
by
  System.out.print("Enter temperature: ");

Replace
  String userInput = SimpleIO.readLine();
  double fahrenheit = Convert.toDouble(userInput);
by
  Scanner input = new Scanner(System.in); //once only
  double fahrenheit = input.nextDouble();
```


2.11 Case Study: Computing a Course Average

- The `CourseAverage` program will calculate a class average, using the following percentages:

Programs	30%
Quizzes	10%
Test 1	15%
Test 2	15%
Final exam	30%

- The user will enter the grade for each program (0–20), the score on each quiz (0–10), and the grades on the two tests and the final (0–100). There will be eight programs and five quizzes.

Output of the **`CourseAverage`** Program

```
Welcome to the CSc 2310 average calculation program.

Enter Program 1 score: 20
Enter Program 2 score: 19
Enter Program 3 score: 15
Enter Program 4 score: 18.5
Enter Program 5 score: 20
Enter Program 6 score: 20
Enter Program 7 score: 18
Enter Program 8 score: 20

Enter Quiz 1 score: 9
Enter Quiz 2 score: 10
Enter Quiz 3 score: 5.5
Enter Quiz 4 score: 8
Enter Quiz 5 score: 9.5

Enter Test 1 score: 78
Enter Test 2 score: 92
Enter Final Exam score: 85

Course average: 88
```


Design of the **`CourseAverage`** Program

1. Print the introductory message ("Welcome to the CSc 2310 average calculation program").
2. Prompt the user to enter eight program scores.
3. Compute the program average from the eight scores.
4. Prompt the user to enter five quiz scores.
5. Compute the quiz average from the five scores.
6. Prompt the user to enter scores on the tests and final exam.
7. Compute the course average from the program average, quiz average, test scores, and final exam score.
8. Round the course average to the nearest integer and display it.

Design of the **`CourseAverage`** Program

- `double` variables can be used to store scores and averages.
- Computing the course average involves scaling the program average and quiz average so that they lie between 0 and 100:

  courseAverage =

  $.30 \times programAverage \times 5 + .10 \times quizAverage \times 10 +$
  $.15 \times test1 + .15 \times test2 + .30 \times finalExam$

- `Math.round` can be used to round the course average to the nearest integer.

`CourseAverage.java`

```
// Program name: CourseAverage
// Author: K. N. King
// Written: 1998-04-05
// Modified: 1999-01-27
//
// Prompts the user to enter eight program scores (0-20), five
// quiz scores (0-10), two test scores (0-100), and a final
// exam score (0-100). Scores may contain digits after the
// decimal point. Input is not checked for validity. Displays
// the course average, computed using the following formula:
//
//   Programs    30%
//   Quizzes     10%
//   Test 1      15%
//   Test 2      15%
//   Final exam  30%
//
// The course average is rounded to the nearest integer.
```

```
import java.util.Scanner;

public class CourseAverage {
  public static void main(String[] args) {
    // Print the introductory message
    System.out.println("Welcome to the CSc 2310 average " +
                       "calculation program.\n");

    Scanner input = new Scanner(System.in);
    // Prompt the user to enter eight program scores
    System.out.print("Enter Program 1 score: ");
    double program1 = input.nextDouble();

    System.out.print("Enter Program 2 score: ");
    double program2 = input.nextDouble();

    System.out.print("Enter Program 3 score: ");
    double program3 = input.nextDouble();
```



```
    System.out.print("Enter Program 4 score: ");
    double program4 = input.nextDouble();

    System.out.print("Enter Program 5 score: ");
    double program5 = input.nextDouble();

    System.out.print("Enter Program 6 score: ");
    double program6 = input.nextDouble();

    System.out.print("Enter Program 7 score: ");
    double program7 = input.nextDouble();

    System.out.print("Enter Program 8 score: ");
    double program8 = input.nextDouble();

    // Compute the program average from the eight scores
    double programAverage =
      (program1 + program2 + program3 + program4 +
       program5 + program6 + program7 + program8) / 8;
```



```
    // Prompt the user to enter five quiz scores
    System.out.print("\nEnter Quiz 1 score: ");
    double quiz1 = input.nextDouble();

    System.out.print("Enter Quiz 2 score: ");
    double quiz2 = input.nextDouble();

    System.out.print("Enter Quiz 3 score: ");
    double quiz3 = input.nextDouble();

    System.out.print("Enter Quiz 4 score: ");
    double quiz4 = input.nextDouble();

    System.out.print("Enter Quiz 5 score: ");
    double quiz5 = input.nextDouble();

    // Compute the quiz average from the five scores
    double quizAverage =
      (quiz1 + quiz2 + quiz3 + quiz4 + quiz5) / 5;
```



```
    // Prompt the user to enter scores on the tests and final
    // exam
    System.out.print("\nEnter Test 1 score: ");
    double test1 = input.nextDouble();

    System.out.print("Enter Test 2 score: ");
    double test2 = input.nextDouble();

    System.out.print("Enter Final Exam score: ");
    double finalExam = input.nextDouble();
```



```
    // Compute the course average from the program average,
    // quiz average, test scores, and final exam score.
    // The program average (0-20) is multiplied by 5 to put
    // it on a scale of 0 to 100. The quiz average (0-10) is
    // multiplied by 10 for the same reason.
    double courseAverage = .30 * programAverage * 5 +
                           .10 * quizAverage * 10 +
                           .15 * test1 +
                           .15 * test2 +
                           .30 * finalExam;

    // Round the course average to the nearest integer and
    // display it
    System.out.println("\nCourse average: " +
                       Math.round(courseAverage));
  }
}
```


Style Issues

- Style issues raised by the `CourseAverage` program:
  - Comment blocks
  - Blank lines
  - Short comments
  - Long lines

Improving the Program

- The values of most variables in the `CourseAverage` program are used only once.
- When a variable's value is used only once, the variable can often be eliminated by substituting the value that's assigned to it. The lines

```
String userInput = SimpleIO.readLine();
double program1 = Convert.toDouble(userInput);
```

  could be replaced by

```
//double program1 =
//  Convert.toDouble(SimpleIO.readLine());
double program1 = input.nextDouble();
```


Improving the Program

- The number of variables in `CourseAverage` can be reduced by keeping a "running total" of all scores entered so far, rather than storing each score in a separate variable:

```
// Prompt the user to enter eight program scores.
System.out.print("Enter Program 1 score: ");
double programTotal = input.nextDouble();

System.out.print("Enter Program 2 score: ");
programTotal += input.nextDouble();
...

// Compute the program average from the eight scores.
double programAverage = programTotal / 8;
```


2.12 Debugging

- ***Debugging*** is the process of finding bugs in a program and fixing them.
- Types of errors:
  - Compile-time errors : level 1
  - Run-time errors (called ***exceptions*** in Java): level 2
  - Logical errors (incorrect behavior) : level 3

Fixing Compile-Time Errors

- Strategies for fixing compile-time errors:
  - Read error messages carefully. Example:

```
Buggy.java:8: Undefined variable: i
    System.out.println(i);
                       ^
Buggy.java:10: Variable j may not have been initialized
    System.out.println(j);
                       ^
```

  - Pay attention to line numbers.
  - Fix the first error.

Fixing Compile-Time Errors

  - Don't trust the compiler (completely). The error isn't always on the line reported by the compiler. Also, the error reported by the compiler may not accurately indicate the nature of the error. Example:

```
System.out.print("Value of i: ")
System.out.println(i);
```

    A semicolon is missing at the end of the first statement, but the compiler reports a different error:

```
Buggy.java:8: Invalid type expression.
    System.out.print("Value of i: ")
                     ^
Buggy.java:9: Invalid declaration.
    System.out.println(i);
                       ^
```


Fixing Run-Time Errors

- When a run-time error occurs, a message will be displayed on the screen. Example:

```
Exception in thread "main"
  java.lang.NumberFormatException: foo
      at java.lang.Integer.parseInt(Compiled Code)
      at java.lang.Integer.parseInt(Integer.java:458)
      at Buggy.main(Buggy.java:11)
```

- Once we know what the nature of the error is and where the error occurred, we can work backwards to determine what caused the error.

Fixing Logical (Behavioral) Errors

- Errors of behavior are the hardest problems to fix, because the problem probably lies either in the original algorithm or in the translation of the algorithm into a Java program.
- Other than simply checking and rechecking the algorithm and the program, there is a simple method to locate the source of a behavioral problem.

Debugging

- If a run-time error occurs in a Java program, the message displayed by the Java interpreter may be enough to identify the bug.
- Also, `System.out.println` can be used to print the values of variables for the purpose of debugging:

```
System.out.println("Value of a: " + a +
                   " Value of b: " + b);
```


Choosing Test Data

- Testing a program usually requires running it more than once, using different input each time.
- One strategy, known as boundary-value testing, involves entering input at the extremes of what the program considers to be legal.
- Boundary-value testing is both easy to do and surprisingly good at revealing bugs.