Expressions in Java

Consider the Java statement: int total = n1 + n2;

▶ This statement combines the values in the integer objects n1 and n2 and places the sum in the integer object total.

▶ The n1 + n2 that appears on the right hand side (RHS) of the assignment operator (=) is an example of an expression, which specifies the operations involved in the computation.

▶ A Java expression consists of terms joined together by operators.

Valid Java Expression Terms

▶ A constant such as 3.141592 or "Hello, World!"

▶ An object name such as n1, n2, or total

▶ A method call that returns a value, such as readInt()

▶ An expression enclosed in parentheses

Constants and Variables

▶ The simplest terms that appear in expressions are constants and variables.

▶ The value of a constant does not change during the course of a program. Go figure!

▶ Declaring constants (by convention, between the last curly braces of the run() method and the class):

```java
private static final int MULTI = 3;
private static final double PI = 3.14159;
private static final double TWO_PI = 2 * PI;
```

▶ DO NOT USE “MAGIC NUMBERS” (aka un-named constants).
Variables

▶ A variable is the name used to identify the piece of memory set aside during execution to hold a value; it can be updated as the program runs.

▶ Each variable has three attributes:
  ▶ name: differentiates one variable from another
  ▶ type: specifies type of value variable can contain
  ▶ value: current contents of the variable

▶ The name and type of a variable are fixed.

▶ The value changes whenever you assign a new value to the variable.

Differences in Storage

\[
\text{total: } \texttt{an int} = 42
\]

\[
\text{minimum: } \texttt{a float} = 0.001096
\]

Variables may be visualized as naming various sizes of shoe boxes (depending on type), and are capable of storing a single value.

Java Identifiers

▶ Names for variables (and other things) are called identifiers.

▶ Identifiers in Java conform to the following rules:
  ▶ Must begin with a letter or underscore
  ▶ Remaining characters must be letters, digits, or underscore
  ▶ Must not be one of Java’s reserved words
  ▶ Should make their purpose obvious to the reader (programmer)
  ▶ Should adhere to standard conventions. (Variable names, for example, usually begin with a lowercase letter; while constants are all uppercase.)

Java Reserved Words

These may not be used as identifiers

<table>
<thead>
<tr>
<th>Keyword</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>abstract</td>
<td>interface</td>
</tr>
<tr>
<td>boolean</td>
<td>super</td>
</tr>
<tr>
<td>break</td>
<td>else</td>
</tr>
<tr>
<td>case</td>
<td>extends</td>
</tr>
<tr>
<td>char</td>
<td>long</td>
</tr>
<tr>
<td>class</td>
<td>native</td>
</tr>
<tr>
<td>const</td>
<td>synchronized</td>
</tr>
<tr>
<td>continue</td>
<td>final</td>
</tr>
<tr>
<td>default</td>
<td>float</td>
</tr>
<tr>
<td>do</td>
<td>goto</td>
</tr>
<tr>
<td>double</td>
<td>implements</td>
</tr>
<tr>
<td>else</td>
<td>if</td>
</tr>
<tr>
<td>import</td>
<td>interface</td>
</tr>
<tr>
<td>instanceof</td>
<td>int</td>
</tr>
<tr>
<td>interface</td>
<td>interface</td>
</tr>
<tr>
<td>instanceof</td>
<td>int</td>
</tr>
<tr>
<td>long</td>
<td>interface</td>
</tr>
<tr>
<td>new</td>
<td>int</td>
</tr>
<tr>
<td>package</td>
<td>short</td>
</tr>
<tr>
<td>protected</td>
<td>static</td>
</tr>
<tr>
<td>private</td>
<td>this</td>
</tr>
<tr>
<td>public</td>
<td>synchronized</td>
</tr>
<tr>
<td>protected</td>
<td>transient</td>
</tr>
<tr>
<td>throw</td>
<td>try</td>
</tr>
<tr>
<td>try</td>
<td>true</td>
</tr>
<tr>
<td>type</td>
<td>volatile</td>
</tr>
<tr>
<td>volatile</td>
<td>void</td>
</tr>
<tr>
<td>while</td>
<td>while</td>
</tr>
<tr>
<td>void</td>
<td>volatile</td>
</tr>
<tr>
<td>while</td>
<td>while</td>
</tr>
<tr>
<td>void</td>
<td>volatile</td>
</tr>
</tbody>
</table>

Variable Declarations

▶ A variable must be declared before it can be used.

▶ The declaration establishes the type and name of the variable.

▶ A common form of a variable declaration is:

\[
\text{type name;}\]

where
  ▶ type is the name of a primitive type or a class
  ▶ name is a unique identifier
  ▶ Note that no value is assigned to the variable — it is considered to be uninitialized.

▶ After a variable is declared, it may then be initialized with an assignment statement:

\[
\text{name = value;}\]

Variable Declarations with Initialization

▶ The declaration may also establish the type, name, and initial value, all in one statement.

▶ Another common form of a variable declaration is:

\[
\text{type name = value;}\]

where
  ▶ type is the name of a primitive type or a class
  ▶ name is a unique identifier, and
  ▶ value is an expression specifying the initial value

▶ The variable can be given another value in an assignment statement, just as before.
Equivalent Examples

// Declare, then initialize
int n1;
int n2;
int total;
n1 = readInt("Enter first integer: ");
n2 = readInt("Enter second integer: ");
total = n1 + n2;

// Declare and initialize in same statement
int n1 = readInt("Enter first integer: ");
int n2 = readInt("Enter second integer: ");
int total = n1 + n2;


Variable Declarations in Class Methods

▶ Most declarations appear as statements in the body of a method definition. Two examples we've seen:
int n1 = readInt("Enter first number: ");
GRect Face = new GRect(LeftX, TopY, FaceWidth, FaceHeight);
▶ Variables declared in methods are called local variables and are accessible (known) only inside the method where they are declared.
▶ Variables may also be declared as part of a class, and then are called instance variables (or data members of the class).

Operators and Operands

▶ Java arithmetic expressions closely resemble mathematical expressions.
▶ The most common operators are the ones that specify arithmetic computation:
  + Addition
  – Subtraction
  * Multiplication
  / Division
  % Remainder
▶ Operators usually appear between two sub–expressions, called operands
▶ binary operator: an operator that take two operands.
▶ The – (minus) operator can also appear as a unary operator, as in the expression –x, which denotes the negative of x.

Integer Division

Whenever you apply a binary operator to numeric values,
the result will be of type int if both operands are of type int, but will be double if either operand (or both) is double.

▶ This rule has important consequences
in the case of division — when two integers are the operands, the resulting quotient is truncated, meaning cut off!

▶ Beware of Integer Division:
3 / 5 is 0
5 / 3 is 1
1292 / 100 is 12

Division and Type Casting

▶ Whenever a binary operator is applied to two integers, the result is an integer.
▶ Whenever a binary operator is applied to at least one double, the result is a double.
▶ What if we want the complete result even when we have two integers? Convert at least one operand to a double:
  (double) n1 / n2
  or  (double) n1 / (double) n2
▶ The conversion is accomplished by means of a type cast, which consists of a type name in parentheses.

The Pitfalls of Integer Division

Consider the following Java statements, intended to convert 100º Celsius temperature to its Fahrenheit equivalent:

double CelsTemp = 100.0;
double FahrTemp = 9 / 5 * CelsTemp + 32;

How will the expression for FahrTemp be evaluated?

How can the problem be solved?

How could the problem have been avoided in the first place?
The modulus operator %

In Java, using the modulus operator results in the remainder when one integer is divided by another integer.

\[ 3 \% 5 \text{ is } 3 \]
\[ 5 \% 3 \text{ is } 2 \]
\[ 1292 \% 100 \text{ is } 92 \]

An error will occur if an attempt is made to use the modulus operator with one or more floating point (double) values.

The modulus operator is useful in a surprising number of programming applications.

Examples

a) \[ 3 \times 5 / 2 \text{ is } 15 / 2 \text{ or } 7 \]
b) \[ 3 / 8 \% 4 \text{ is } 0 \% 4 \text{ or } 0 \]
c) \[ 3 / (8 \% 4) \text{ is } 3 / 0 \text{ or undefined – nan} \]
d) \[ 5 - 2 \times 3 \text{ is } 5 - 6 \text{ or } -1 \]
e) \[ 5 \times 2 - 3 \text{ is } 10 - 3 \text{ or } 7 \]
f) \[ 5 \times 2 / 3 \text{ is } 10 / 3 \text{ or } 3 \]
g) \[ 8 - 6 \times 2 + 7 \% 2 \text{ is } 8 - 12 + 7 \% 2 = 8 - 12 + 1 = -3 \]

Precedence or Hierarchy of Operations

If an expression contains more than one operator, precedence rules are used to determine the order of evaluation.

From highest to lowest precedence:

- Expressions in Parentheses
- Unary minus (−), type casting
- Multiplication and Division (left to right) (includes the modulus operator %)
- Addition and Subtraction (left to right)

Examples of Mixed Mode Arithmetic

When both integer and double values are used in the same arithmetic expression, the partial result remains an integer until a floating point value is involved as an operand during the evaluation.

\[ 2 / 5 / 4.0 \text{ is } 0 / 4.0 \text{ or } 0.0 \]
\[ 2 / (5 / 4.0) \text{ is } 2 / 1.25 \text{ or } 1.6 \]
\[ 5.0 \times 2 / 4 \text{ is } 10.0 / 4 \text{ or } 2.5 \]
\[ 5.0 \times (2 / 4) \text{ is } 5.0 \times 0 \text{ or } 0.0 \]

What is the value of:

\[ (1 + 2) \% 3 \times 4 + 5 \times 6 / 7 \times (8 \% 9) + 10? \]

Assignment Statements

- The value of a variable in a program can be changed by using an assignment statement, which has the general form:

  \[ \text{variable } = \text{ expression;} \]

- The value of the expression on the right hand side is computed and assigned to the variable that appears on the left.

- The assignment statement: \[ \text{total } = \text{ total + tax;} \] adds the current values of the variables total and tax, then stores that sum back in the variable total.

- When a new value is assigned to a variable, the old value is lost.

Shorthand Assignments

- Statements such as \[ \text{total } = \text{ total + tax;} \] are so common that Java allows the following shorthand form: \[ \text{total } += \text{ tax;} \]

- The general form of shorthand assignment is:

  \[ \text{variable op= expression;} \]

  where \text{op} is any of Java’s binary operators (\text{+ / * %}).

- The effect of this statement is the same as:

  \[ \text{variable = variable op= expression;} \]

To triple the value of salary: \[ \text{salary } *= 3; \]
Auto-Increment and Decrement Operators

- Another common computation is to add or subtract one from an integer.
- Java provides several methods for incrementing and decrementing.
- To increment:
  \[ x = x + 1; \quad x += 1; \quad x++; \]
- To Decrement:
  \[ x = x - 1; \quad x -= 1; \quad x--; \]

Applications of Integer Arithmetic

- Integer division and the modulus operator can be used to group quantities together or to extract groups from larger quantities.

Example

Suppose we have:

- several buckets of eggs,
- egg cartons (capable of holding 12 eggs each)
- we want to box the eggs so all cartons are full except perhaps the last one if we don't have a multiple of 12 eggs

Given the number of eggs, how do we calculate the minimum number of egg cartons needed to transport them safely?

Discovering an Expression

Suppose there are \( x \) eggs... Let \( j \) be the number of cartons:

\[
12j - 11 \leq x \leq 12j \\
(12j - 11) + 11 \leq x + 11 \leq 12j + 11 \\
12j \leq x + 11 \leq 12j + 11 \\
\frac{j}{12} \leq \frac{x + 11}{12} \leq \frac{12j + 11}{12} \\
\]

\[ j \leq \frac{x + 11}{12} \leq \frac{12j + 11}{12} \]

\[
\text{int numberOfCartons} = \frac{(\text{numberOfEggs} + 11)}{12};
\]

Furthermore...

Suppose we have a contract with a restaurant to supply eggs in cartons of 3 and 7 eggs each. To determine how to package the eggs:

\[
\text{// number of groups of 7} \\int \text{numberOfSevens} = \frac{\text{numberOfEggs}}{7};
\]

\[
\text{// number of groups of 3 from eggs remaining} \int \text{numberOfThrees} = \frac{\text{numberOfEggs} \% 7}{3};
\]

\[
\text{// 0, 1, or 2 eggs leftover after boxing the rest} \int \text{leftOver} = \frac{\text{numberOfEggs} \% 7 \% 3};
\]
Alternatively, Store Intermediate Values

// number of groups of 7
int numberOfSevens = numberOfEggs / 7;
// number of eggs left after grouping by 7 (0 - 6)
int remaining = numberOfEggs % 7;
// number of groups of 3 from eggs remaining
int numberOfThrees = remaining / 3;
// 0, 1, or 2 eggs leftover after boxing the rest
int leftOver = remaining % 3;

Boolean Expressions

▶ The only values in the boolean domain are true and false
▶ The boolean type provides exactly the values needed in order for programs to make decisions.
▶ The boolean type is named for the English mathematician, George Boole, who introduced a system of logic now known as Boolean algebra, the foundation for the boolean data type.
▶ The operators used with the boolean data type fall into two categories: relational and logical.

Boolean Operators

▶ There are six relational operators that compare values of other types and produce a boolean result.
  - == Equals
  - != Not equal
  - < Less than
  - <= Less or equal to
  - > Greater than
  - >= Greater or equal to

▶ There are also three logical operators, which are used with boolean operands:
  - && Logical AND
  - || Logical OR
  - ! Logical NOT

Notes on the Boolean Operators

▶ Remember that Java uses "=" to denote assignment. To test for equality, use the "==" operator.
▶ It is not legal in Java to use more than one relational operator in a single comparison, as is often done in mathematics. To express the compound inequality
  \[ 0 \leq x \leq 9 \]
  in Java, make both comparisons explicit, as in
  \[ 0 \leq x \land x \leq 9 \]
▶ The || operator means either or both
▶ Be careful when you combine the ! operator with && and || because the interpretation often differs from informal English.

Short–Circuit Evaluation

▶ The && and || operators are evaluated using a strategy called short–circuit mode which evaluates the right operand only if it needs to do so.
  - In &&, if the left operand is false, there is no need to evaluate the right operand because false && anything is always false
  - In ||, if the left operand is true, there is no need to evaluate the right operand because true || anything is always true

Designing for Change

▶ While it is necessary for you to write programs the compiler can understand, good programmers are equally concerned with writing code that people can understand.
▶ Programs must be maintained over their life cycle, hence human readability is important.
▶ Typically, as much as 90 percent of the programming effort comes after the initial release of a system.
Good Programming Style

There are several useful techniques that you can adopt to increase readability:

▶ Named constants enhance both readability and maintainability
▶ Proper indentation helps make program structure clear; use `ctrl-shift-F` to reformat statements in NetBeans. You can also right-click in the editor and select `Format` to do the same thing.
▶ The purpose of variables and methods should be clearly expressed in their names

---

Primitive Data Types

Java defines eight primitive types to represent simple data. The programs in our text use only the following four:

<table>
<thead>
<tr>
<th>Type</th>
<th>Size</th>
<th>Range of Values</th>
</tr>
</thead>
<tbody>
<tr>
<td><code>int</code></td>
<td>represents integers, which are whole numbers such as <code>17</code> or <code>-53</code></td>
<td></td>
</tr>
<tr>
<td><code>double</code></td>
<td>represents numbers that include a decimal fraction, such as <code>3.14159265</code></td>
<td></td>
</tr>
<tr>
<td><code>boolean</code></td>
<td>represents a logical value, either <code>true</code> or <code>false</code></td>
<td></td>
</tr>
<tr>
<td><code>char</code></td>
<td>represents a single character</td>
<td></td>
</tr>
</tbody>
</table>

* Such values are called floating-point numbers; the name `double` comes from the fact that the representation uses twice the minimum precision.

---

Summary of Primitive Java Types & Operations

<table>
<thead>
<tr>
<th>Type</th>
<th>Common Operations</th>
</tr>
</thead>
<tbody>
<tr>
<td>byte</td>
<td>The arithmetic operators: add(+) subtract(-) multiply(*)</td>
</tr>
<tr>
<td>short</td>
<td>divide(/) remainder(%)</td>
</tr>
<tr>
<td>int</td>
<td>The relational operators: equal to (==) less than (&lt;) greater than (&gt;)</td>
</tr>
<tr>
<td>long</td>
<td>not equal (!=) less or equal (&lt;=) greater or equal (&gt;=)</td>
</tr>
<tr>
<td>float</td>
<td>The arithmetic operators except %</td>
</tr>
<tr>
<td>double</td>
<td>The relational operators</td>
</tr>
<tr>
<td>char</td>
<td>The relational operators</td>
</tr>
<tr>
<td>boolean</td>
<td>The logical operators: &amp;&amp; (and)</td>
</tr>
</tbody>
</table>

---

Summary of Primitive Java Types — Domains

A data type is defined by
1. a set of values and
2. a set of operations

Here are the Java primitive type domains:

<table>
<thead>
<tr>
<th>Type</th>
<th>Size</th>
<th>Range of Values</th>
</tr>
</thead>
<tbody>
<tr>
<td>byte</td>
<td>8-bit integers</td>
<td>-128 to 127</td>
</tr>
<tr>
<td>short</td>
<td>16-bit integers</td>
<td>-32,768 to 32,767</td>
</tr>
<tr>
<td>int</td>
<td>32-bit integers</td>
<td>-2,146,483,648 to 2,146,483,647</td>
</tr>
<tr>
<td>long</td>
<td>64-bit integers</td>
<td>-9,223,372,036,754,775,808 to 9,223,372,036,754,775,807</td>
</tr>
<tr>
<td>char</td>
<td>16-bit characters encoded using Unicode</td>
<td></td>
</tr>
<tr>
<td>boolean</td>
<td>the values <code>true</code> and <code>false</code></td>
<td></td>
</tr>
</tbody>
</table>