Building Java Programs

Chapter 2
Lecture 2-1: Expressions and Variables

reading: 2.1 - 2.2

Data and expressions

reading: 2.1

Data types

- **type**: A category or set of data values.
  - Constrains the operations that can be performed on data
  - Many languages ask the programmer to specify types
  - Examples: integer, real number, string
- Internally, computers store everything as 1s and 0s

```
104    → 01101000
"hi"   → 0110100001101001
```


Java's primitive types

- **primitive types**: 8 simple types for numbers, text, etc.
  - Java also has **object types**, which we'll talk about later

Name	Description		Examples
`int`	integers	(up to $2^{31}-1$)	`42, -3, 0, 926394`
`double`	real numbers	(up to 10^{308})	`3.1, -0.25, 9.4e3`
`char`	single text characters		`'a', 'X', '?', '\n'`
`boolean`	logical values		`true, false`

  - Why does Java distinguish integers vs. real numbers?

Expressions

- **expression**: A value or operation that computes a value.
  - Examples:

```
1 + 4 * 5
(7 + 2) * 6 / 3
42
```

  - The simplest expression is a *literal value*.
  - A complex expression can use operators and parentheses.

Arithmetic operators

- **operator**: Combines multiple values or expressions.

`+`	addition
`-`	subtraction (or negation)
`*`	multiplication
`/`	division
`%`	modulus (a.k.a. remainder)

- As a program runs, its expressions are *evaluated*.
  - `1 + 1` evaluates to `2`
  - `System.out.println(3 * 4);` prints `12`
    - How would we print the text `3 * 4` ?

Integer division with /

- When we divide integers, the quotient is also an integer.
  - `14 / 4` is `3`, not `3.5`

```
  3          4          52
4 ) 14    10 ) 45    27 ) 1425
 12         40         135
  2          5          75
                        54
                        21
```

- More examples:
  - `32 / 5` is `6`
  - `84 / 10` is `8`
  - `156 / 100` is `1`
  - Dividing by 0 causes an error when your program runs.

Integer remainder with %

- The `%` operator computes the remainder from integer division.
  - `14 % 4` is `2`
  - `218 % 5` is `3`

```
  3          43
4 ) 14     5 ) 218
 12         20
  2         18
            15
             3
```

What is the result?

```
45 % 6
2 % 2
8 % 20
11 % 0
```

- Applications of `%` operator:
  - Obtain last digit of a number: `230857 % 10` is `7`
  - Obtain last 4 digits: `658236489 % 10000` is `6489`
  - See whether a number is odd: `7 % 2` is `1`, `42 % 2` is `0`

Precedence

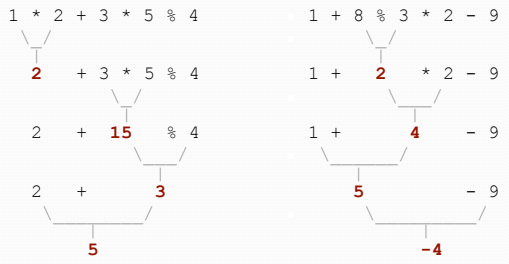
- **precedence**: Order in which operators are evaluated.
  - Generally operators evaluate left-to-right.
    `1 - 2 - 3` is `(1 - 2) - 3` which is `-4`
  - But `* / %` have a higher level of precedence than `+ -`

```
1 + 3 * 4          is 13

6 + 8 / 2 * 3
6 +   4   * 3
6 +     12         is 18
```

  - Parentheses can force a certain order of evaluation:
    `(1 + 3) * 4` is `16`
  - Spacing does not affect order of evaluation
    `1+3 * 4-2` is `11`

Precedence examples



Precedence questions

- What values result from the following expressions?
  - `9 / 5`
  - `695 % 20`
  - `7 + 6 * 5`
  - `7 * 6 + 5`
  - `248 % 100 / 5`
  - `6 * 3 - 9 / 4`
  - `(5 - 7) * 4`
  - `6 + (18 % (17 - 12))`

Real numbers (type `double`)

- Examples: `6.022`, `-42.0`, `2.143e17`
  - Placing `.0` or `.` after an integer makes it a `double`.
- The operators `+ - * / % ()` all still work with `double`.
  - `/` produces an exact answer: `15.0 / 2.0` is `7.5`
  - Precedence is the same: `()` before `* / %` before `+ -`

Real number example

```
2.0 * 2.4 + 2.25 * 4.0 / 2.0
  \___/
4.8     + 2.25 * 4.0 / 2.0
            \___/
4.8     +   9.0    / 2.0
              \_____/
4.8     +          4.5
  \_______________/
           9.3
```


Mixing types

- When `int` and `double` are mixed, the result is a `double`.
  - `4.2 * 3` is `12.6`
- The conversion is per-operator, affecting only its operands.

```
7 / 3 * 1.2 + 3 / 2
  \___/
2   * 1.2 + 3 / 2
      \___/
2.4     + 3 / 2
          \___/
2.4     +   1
  \_____/
    3.4
```

```
2.0 + 10 / 3 * 2.5 - 6 / 4
      \____/
2.0 +    3   * 2.5 - 6 / 4
           \____/
2.0 +      7.5     - 6 / 4
                       \___/
2.0 +      7.5     -   1
  \_____/
    9.5             -   1
      \_____________/
            8.5
```

- `3 / 2` is `1` above, not `1.5`.

String concatenation

- **string concatenation**: Using `+` between a string and another value to make a longer string.

```
"hello" + 42     is "hello42"
1 + "abc" + 2    is "1abc2"
"abc" + 1 + 2    is "abc12"
1 + 2 + "abc"    is "3abc"
"abc" + 9 * 3    is "abc27"
"1" + 1          is "11"
4 - 1 + "abc"    is "3abc"
```

- Use `+` to print a string and an expression's value together.
  - `System.out.println("Grade: " + (95.1 + 71.9) / 2);`
  - Output: `Grade: 83.5`

Variables

reading: 2.2

Receipt example

What's bad about the following code?

```
public class Receipt {
    public static void main(String[] args) {
        // Calculate total owed, assuming 8% tax / 15% tip
        System.out.println("Subtotal:");
        System.out.println(38 + 40 + 30);
        System.out.println("Tax:");
        System.out.println((38 + 40 + 30) * .08);
        System.out.println("Tip:");
        System.out.println((38 + 40 + 30) * .15);
        System.out.println("Total:");
        System.out.println(38 + 40 + 30 +
                           (38 + 40 + 30) * .08 +
                           (38 + 40 + 30) * .15);
    }
}
```

- The subtotal expression `(38 + 40 + 30)` is repeated
- So many `println` statements

Variables

- **variable**: A piece of the computer's memory that is given a name and type, and can store a value.
  - Like preset stations on a car stereo, or cell phone speed dial:


- Steps for using a variable:
  - *Declare* it - state its name and type
  - *Initialize* it - store a value into it
  - *Use* it - print it or use it as part of an expression

Declaration

- **variable declaration**: Sets aside memory for storing a value.
  - Variables must be declared before they can be used.
- Syntax:

  type name;
  - The name is an *identifier*.
- `int zipcode;`

zipcode	

- `double myGPA;`

myGPA	

Assignment

- **assignment**: Stores a value into a variable.
  - The value can be an expression; the variable stores its result.
- Syntax:

  name = **expression**;
- `int zipcode;`
  `zipcode = 90210;`

zipcode	90210

- `double myGPA;`
  `myGPA = 1.0 + 2.25;`

myGPA	3.25

Using variables

- Once given a value, a variable can be used in expressions:

```
int x;
x = 3;
System.out.println("x is " + x);      // x is 3
System.out.println(5 * x - 1);        // 5 * 3 - 1
```

- You can assign a value more than once:

x	11

```
int x;
x = 3;
System.out.println(x + " here");      // 3 here

x = 4 + 7;
System.out.println("now x is " + x); // now x is 11
```


Declaration/initialization

- A variable can be declared/initialized in one statement.
- Syntax:

  type name = **value**;
- `double myGPA = 3.95;`

myGPA	3.95

- `int x = (11 % 3) + 12;`

x	14

Assignment and algebra

- Assignment uses = , but it is not an algebraic equation.
  - = means, *"store the value at right in variable at left"*
    - The right side expression is evaluated first, and then its result is stored in the variable at left.
- What happens here?

```
int x = 3;
x = x + 2;    // ???
```

x	5

Assignment and types

- A variable can only store a value of its own type.
  - `int x = 2.5;` **// ERROR: incompatible types**
- An `int` value can be stored in a `double` variable.
  - The value is converted into the equivalent real number.
- `double myGPA = 4;`

myGPA	4.0

- `double avg = 11 / 2;`
  - Why does `avg` store `5.0` and not `5.5` ?

avg	5.0

Compiler errors

- A variable can't be used until it is assigned a value.
  - `int x;`
    `System.out.println(x);` **`// ERROR: x has no value`**
- You may not declare the same variable twice.
  - `int x;`
    `int x;` **`// ERROR: x already exists`**
  - `int x = 3;`
    `int x = 5;` **`// ERROR: x already exists`**
    - How can this code be fixed?

Printing a variable's value

- Use + to print a string and a variable's value on one line.
  - ```
    double grade = (95.1 + 71.9 + 82.6) / 3.0;
    System.out.println("Your grade was " + grade);

    int students = 11 + 17 + 4 + 19 + 14;
    System.out.println("There are " + students +
                       " students in the course.");
    ```
  - Output:

    ```
    Your grade was 83.2
    There are 65 students in the course.
    ```


Receipt question

Improve the receipt program using variables.

```
public class Receipt {
    public static void main(String[] args) {
        // Calculate total owed, assuming 8% tax / 15% tip
        System.out.println("Subtotal:");
        System.out.println(38 + 40 + 30);

        System.out.println("Tax:");
        System.out.println((38 + 40 + 30) * .08);

        System.out.println("Tip:");
        System.out.println((38 + 40 + 30) * .15);

        System.out.println("Total:");
        System.out.println(38 + 40 + 30 +
                           (38 + 40 + 30) * .15 +
                           (38 + 40 + 30) * .08);
    }
}
```


Receipt answer

```
public class Receipt {
    public static void main(String[] args) {
        // Calculate total owed, assuming 8% tax / 15% tip
        int subtotal = 38 + 40 + 30;
        double tax = subtotal * .08;
        double tip = subtotal * .15;
        double total = subtotal + tax + tip;

        System.out.println("Subtotal: " + subtotal);
        System.out.println("Tax: " + tax);
        System.out.println("Tip: " + tip);
        System.out.println("Total: " + total);
    }
}
```
```