

# **Building Java Programs**

## **Chapter 2**

Primitive Data and Definite Loops

# 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" → 01101000110101

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

- 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

$$\begin{array}{r} 3 \\ 4 \overline{) 14} \\ \underline{12} \\ 2 \end{array}$$

$$\begin{array}{r} 4 \\ 10 \overline{) 45} \\ \underline{40} \\ 5 \end{array}$$

$$\begin{array}{r} 52 \\ 27 \overline{) 1425} \\ \underline{135} \\ 75 \\ \underline{54} \\ 21 \end{array}$$

- 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

$$\begin{array}{r} 3 \\ 4 \overline{) 14} \\ \underline{12} \\ 2 \end{array}$$

$$\begin{array}{r} 43 \\ 5 \overline{) 218} \\ \underline{20} \\ 18 \\ \underline{15} \\ 3 \end{array}$$

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:

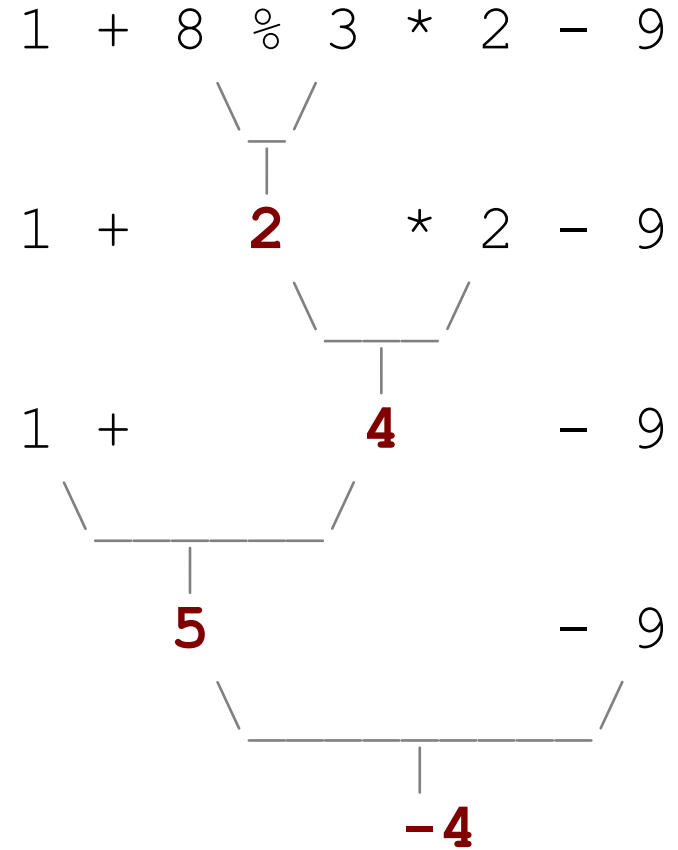
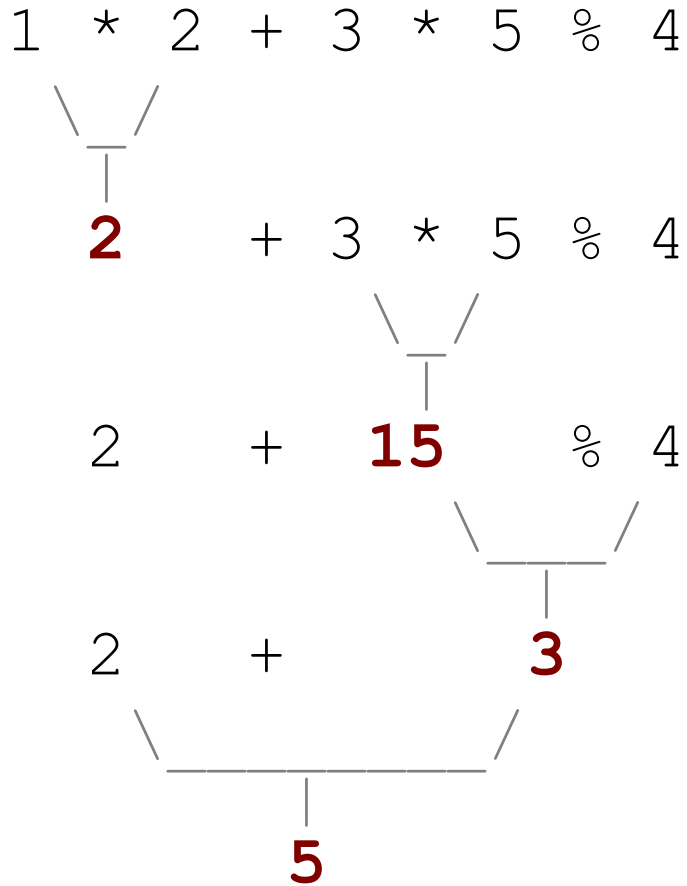
(1 + 3) \* 4 is 16

- 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)

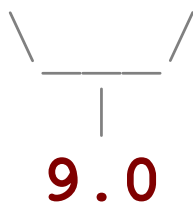
- Examples: `6.022` , `-42.0` , `2.143e17`
  - Placing `.0` or `.` after an integer makes it a `double`.
- The operators `+` `-` `*` `/` `%` `()` all still work with `double`.
  - `/` produces an exact answer: `15.0 / 2.0` is `7.5`
  - Precedence is the same: `()` before `*` `/` `%` before `+` `-`

# Real number example

2.0 \* 2.4 + 2.25 \* 4.0 / 2.0

  
**4.8**

+ 2.25 \* 4.0 / 2.0

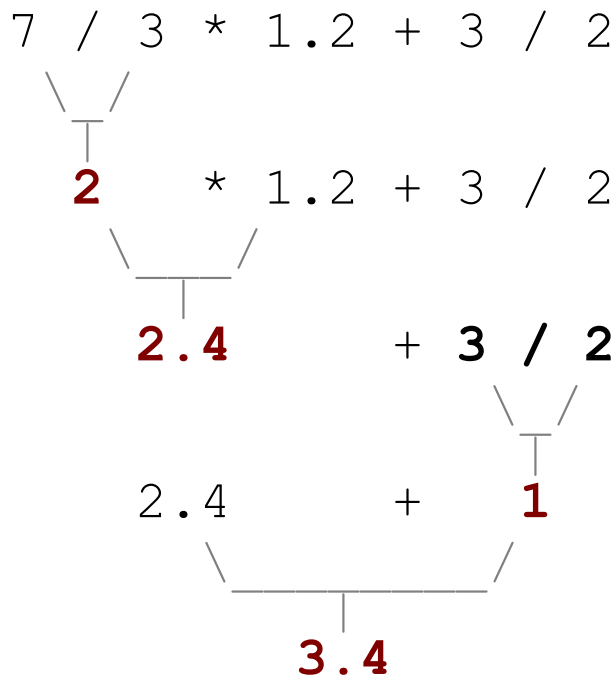
4.8 +  **9.0** / 2.0

4.8 +  **4.5**

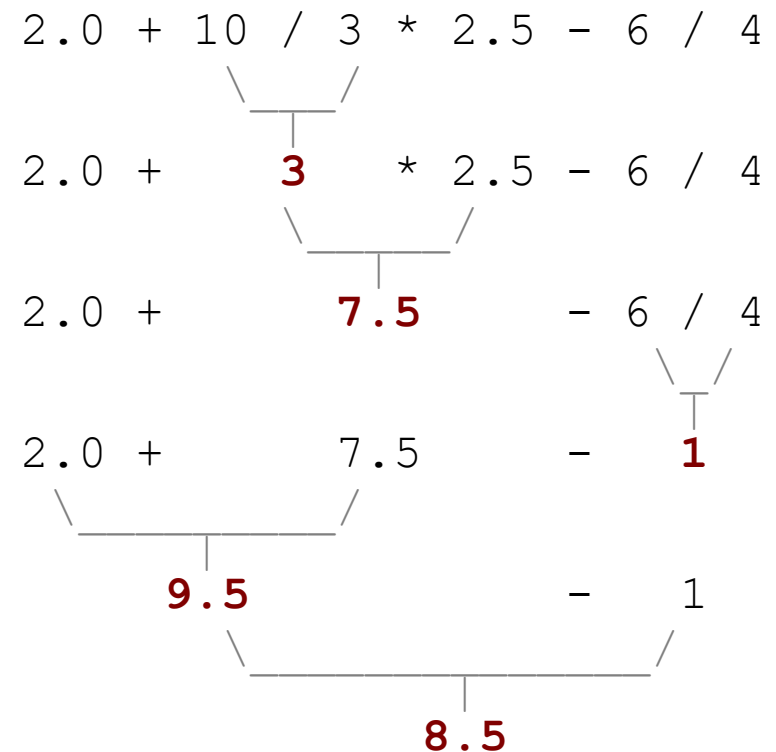
  
**9.3**

# 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.



`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

# 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 x;`



– `double myGPA;`



# Assignment

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

- Syntax:

**name = expression;**

```
- int x;  
  x = 3;
```

|   |   |
|---|---|
| x | 3 |
|---|---|

```
- 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:

```
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;`

|     |     |
|-----|-----|
| avg | 5.0 |
|-----|-----|

- Why does `avg` store 5.0 and not 5.5 ?

# 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);
    }
}
```