

# Building Java Programs

## Chapter 2

### Lecture 2-1: Expressions and Variables

**reading: 2.1 - 2.2**

# Data and expressions

**reading: 2.1**

self-check: 1-4

videos: Ch. 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" → 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

<b>Name</b>	<b>Description</b>	<b>Examples</b>
<code>int</code>	integers	<code>42, -3, 0, 926394</code>
<code>double</code>	real numbers	<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

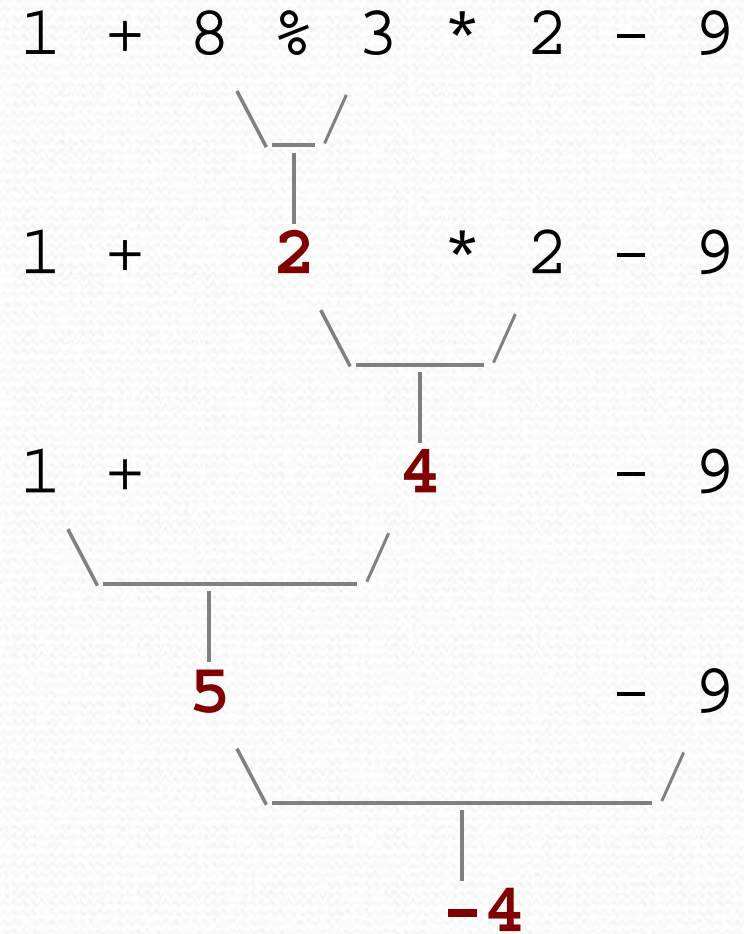
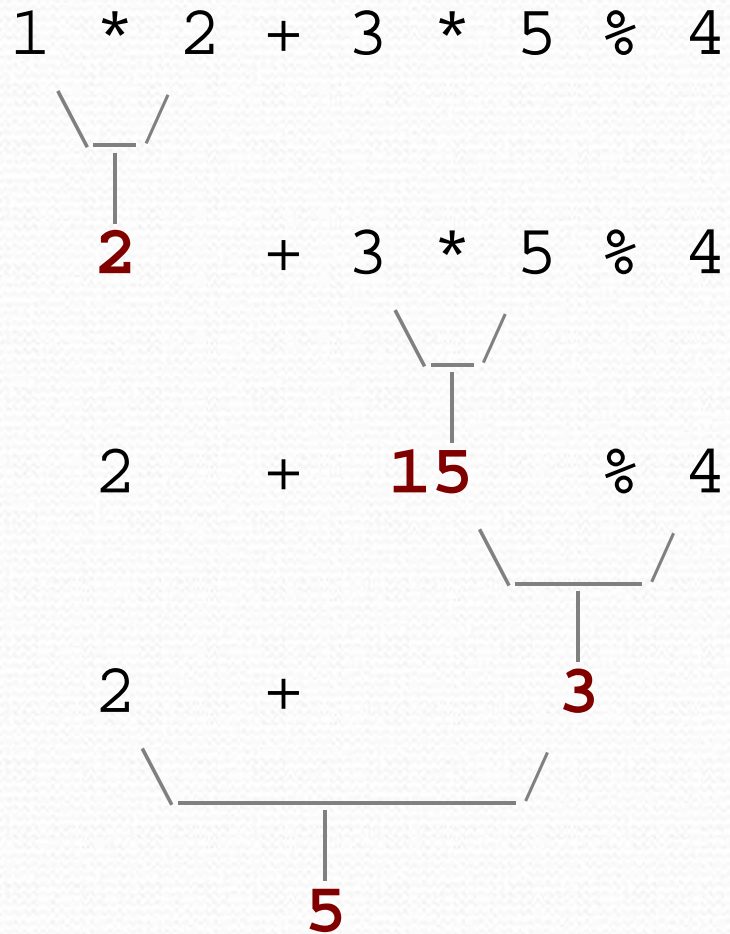
- Parentheses can force a certain order of evaluation:

$(1 + 3) * 4$  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**

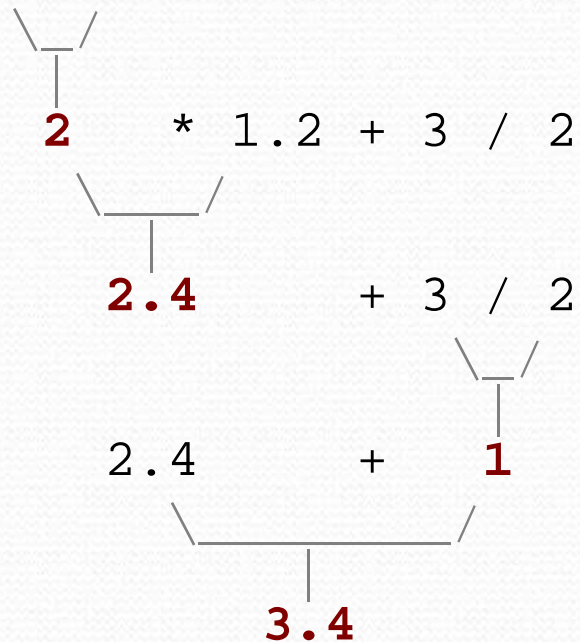


**9.3**

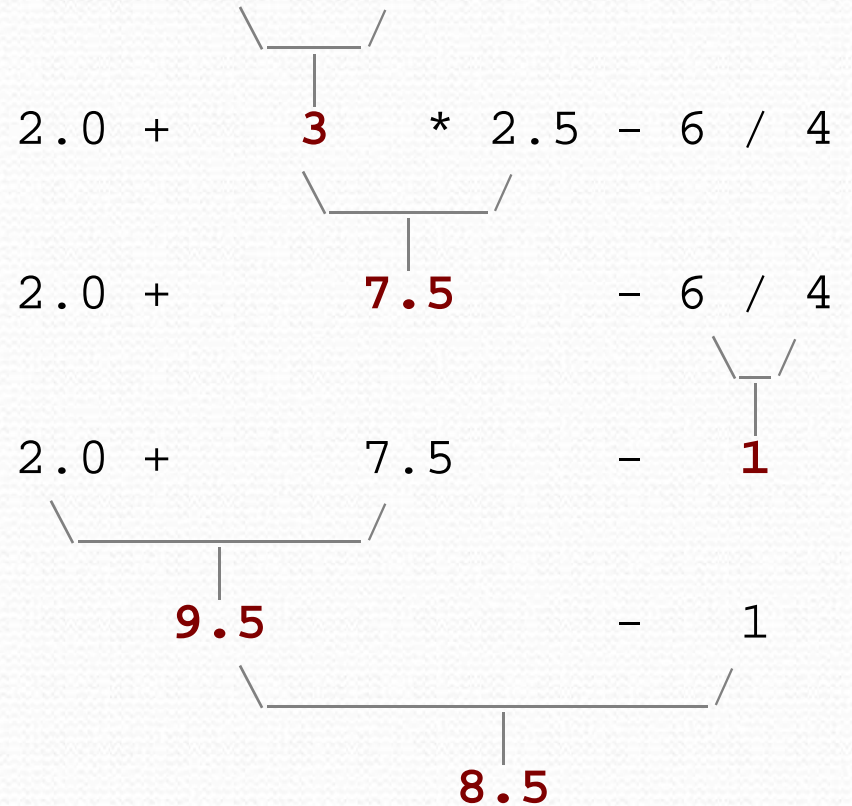
# Mixing types

- 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.

$$7 / 3 * 1.2 + 3 / 2$$



$$2.0 + 10 / 3 * 2.5 - 6 / 4$$



- $3 / 2$  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**

self-check: 1-15

exercises: 1-4

videos: Ch. 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 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;`

- `double myGPA;`

- `myGPA = 1.0 + 2.25;`

x	3
---	---

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;`

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

x	14
---	----

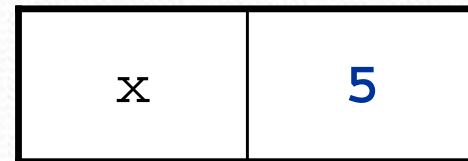
myGPA	3.95
-------	------

# Assignment and algebra

- Assignment uses = , but it is not an algebraic equation.
  - = means, "store the value at right in variable at left"
  - `x = 3;` means "x becomes 3" or "x should now store 3"
- What happens here?

```
int x = 3;
```

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



# 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);
    }
}
```

# 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);  
    }  
}
```