

Unit 1: Primitive Types

Arithmetic Operations

Adapted from:

- 1) Building Java Programs: A Back to Basics Approach
by Stuart Reges and Marty Stepp
- 2) Runestone CSAwesome Curriculum

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

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

$$\begin{array}{r} \overline{52} \\ 27 \) \ 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. This error is also called an **ArithmeticException**.

Integer remainder with %

- The % operator computes the remainder from integer division.

– $14 \% 4$ is 2

– $218 \% 5$ is 3

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

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

Answers:

3, 0, 8, error!, -1

- 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

% Example

```
public static void main(String[] args) {  
    System.out.println(45 % 6);  
    System.out.println(2 % 2);  
    System.out.println(8 % 10);  
    System.out.println(11 % 0);  
    System.out.println(-21 % 4); // not on AP  
    System.out.println(21 % -4); // not on AP  
}
```

Output:

3

0

8

ArithmeticException

-1

1

Expressions

Find the exact change for 137 cents using quarters, dimes, nickels and cents. Use the least number of coins.

How many quarters? $137 / 25 = 5$ quarters (Integer Division!)

What's leftover? $137 \% 25 = 12$ cents

How many dimes? $12 / 10 = 1$ dime

What's leftover? $12 \% 10 = 2$ cents

How many nickels? $2 / 5 = 0$ nickels.

What's leftover? $2 \% 5 = 2$ cents.

Even or Odd

An important use of the % operator is to test for divisibility. For example, is a number even or odd? Is a number a multiple of 3?

```
// a number is even if it has no remainder
```

```
// when divided by 2.
```

```
if (number % 2 == 0) {
```

```
    ...
```

```
}
```

```
// multiple of 3
```

```
if (number % 3 == 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

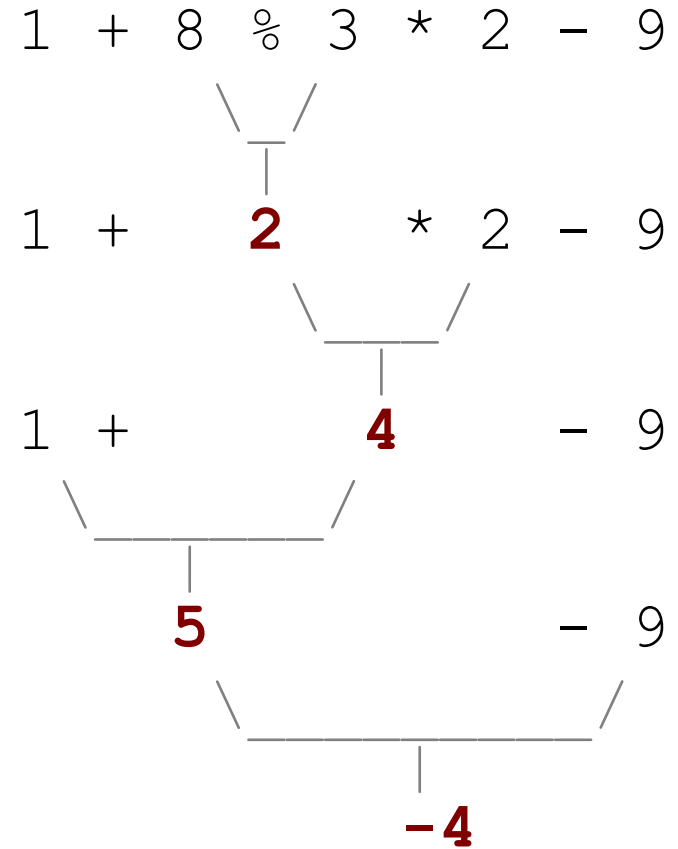
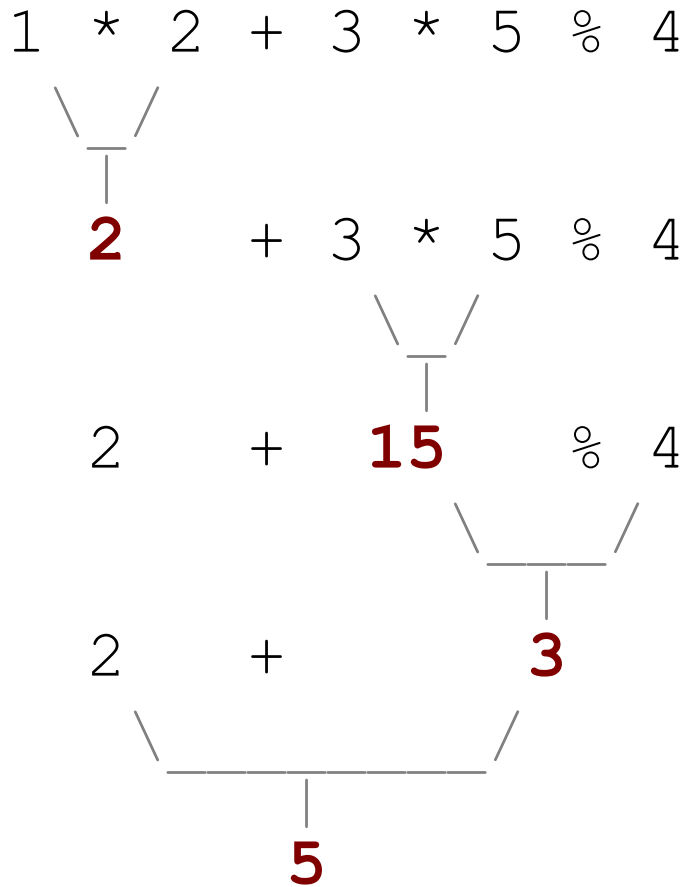
- Parentheses can force a certain order of evaluation:

(1 + 3) * 4 is 16

- Spacing does not affect order of evaluation

1+3 * 4-2 is 11

Precedence examples



Real numbers (type double)

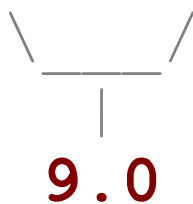
- Examples: `6.022` , `-42.0` , `2.143`
 - Placing `.0` or `.` after an integer makes it a `double`.
- The operators `+` `-` `*` `/` `%` `()` all still work with `double`.
 - `/` produces an exact answer: `15.0 / 2.0` is `7.5`
 - Precedence is the same: `()` before `*` `/` `%` before `+` `-`

Real number example

2.0 * 2.4 + 2.25 * 4.0 / 2.0


4.8

+ 2.25 * 4.0 / 2.0

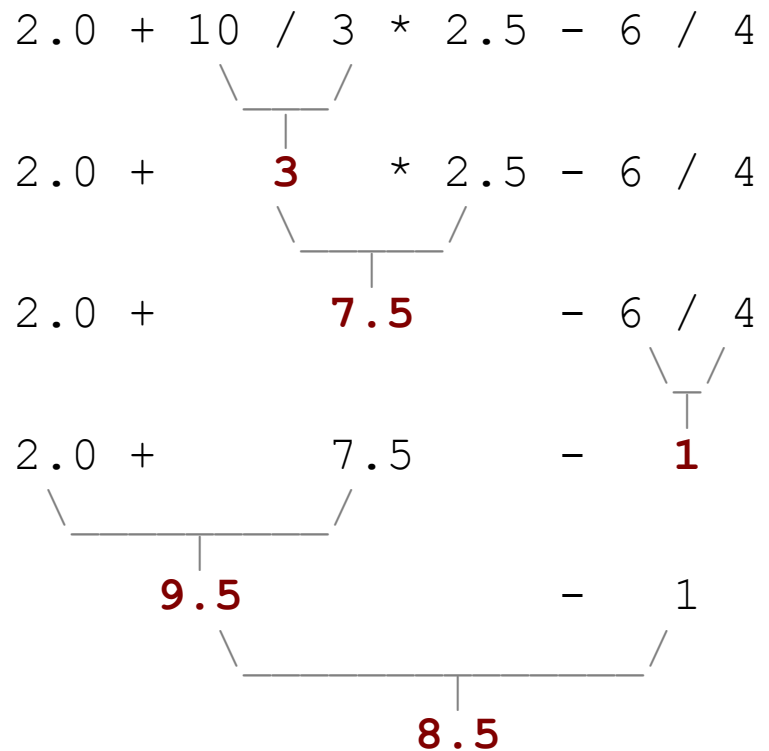
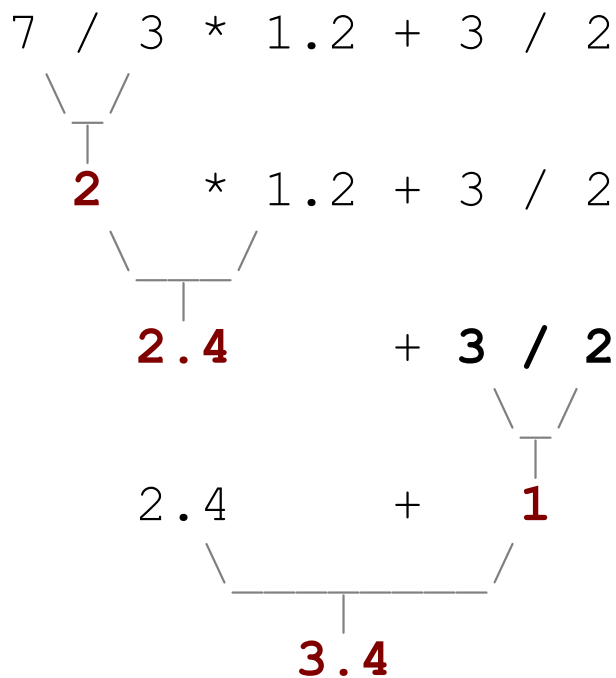
4.8 +  **9.0** / 2.0

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`.

Mixing types

- In Java, **type casting** is used to convert variables from one type to another.

```
public class Test{  
    public static void main(String[] args){  
        System.out.println(1 / 3);  
        System.out.println(1.0 / 3);  
        System.out.println(1 / 3.0);  
        System.out.println((double) 1 / 3);  
    }  
}
```

```
}
```

```
0
```

```
0.3333333333333333
```

```
0.3333333333333333
```

```
0.3333333333333333
```

Type casting

- **type cast:** A conversion from one type to another.
 - To promote an `int` into a `double` to get exact division from `/`
 - To truncate a `double` from a real number to an integer

- Syntax:

(type) expression

Examples:

```
double result = (double) 19 / 5;           // 3.8
int result2 = (int) result;                 // 3
int x = (int) Math.pow(10, 3);              // 1000
```

More about type casting

- Type casting has high precedence and only casts the item immediately next to it.

```
- double x = (double) 1 + 1 / 2;           // 1.0  
- double y = 1 + (double) 1 / 2;           // 1.5
```

- You can use parentheses to force evaluation order.

```
- double average = (double) (a + b + c) / 3;
```

- A conversion to `double` can be achieved in other ways.

```
- double average = 1.0 * (a + b + c) / 3;
```


Casting Example

```
public static void main(String[] args) {  
    double x = 4 / 3;  
    double y = (double) (125/10);  
    double z = (double) 28 / 5;  
    System.out.println(x + " " + y + " " + z);  
    int a =  
}
```

Output:

1.0 12.0 5.6

Round to the nearest integer

- casting can be used to round a number to its nearest integer .

```
double number = 10 / 3;
```

```
// round a positive number to its nearest integer
```

```
int nearestInt = (int)(number + 0.5);
```

```
double negNumber = -10 / 3;
```

```
// round a positive number to its nearest integer
```

```
int nearestNegInt = (int)(negNumber - 0.5);
```

What is the value of nearestInt and nearestNegInt?

Answer: 3 and -3

Increment and decrement

shortcuts to increase or decrease a variable's value by 1

Shorthand

variable++;

variable--;

```
int x = 2;
```

```
x++;
```

```
double gpa = 2.5;
```

```
gpa--;
```

Equivalent longer version

variable = **variable** + 1;

variable = **variable** - 1;

```
// x = x + 1;
```

```
// x now stores 3
```

```
// gpa = gpa - 1;
```

```
// gpa now stores 1.5
```

Modify-and-assign

shortcuts to modify a variable's value

Shorthand

variable += **value**;
variable -= **value**;
variable *= **value**;
variable /= **value**;
variable %= **value**;

Equivalent longer version

variable = **variable** + **value**;
variable = **variable** - **value**;
variable = **variable** * **value**;
variable = **variable** / **value**;
variable = **variable** % **value**;

x += 3;

gpa -= 0.5;

number *= 2;

// x = x + 3;

// gpa = gpa - 0.5;

// number = number * 2;

Code Tracing

What are the values of x, y and z after tracing through the following code?

```
int x = 0;  
int y = 5;  
int z = 1;  
x++;  
y -= 3;  
z = x + z;  
x = y * z;  
y %= 2;  
z--;
```

Lab 1

- Let $\{a_1, a_2, a_3, \dots, a_n\}$ be a list of n real numbers.
- The average of the list is **ave** $= (a_1 + a_2 + \dots + a_n) / n$.
- The variance of the list =
$$[(a_1 - \text{ave})^2 + (a_2 - \text{ave})^2 + \dots + (a_n - \text{ave})^2] / n$$
- The standard deviation of the list = the square root of the variance of the list.

Lab 1

For example, if the list is {2,4,5,8,16}.

Average=7.0

Variance= $[(-5.0)^2 + (-3.0)^2 + (-2.0)^2 + 1.0^2 + 9.0^2]/5 = 24.0$

Standard deviation=square root of 24.0=4.898979486

Lab 1

Create a new repl on repl.it and follow the comments below to write a program that compute some statistics.

```
public class Statistics
{
    public static void main(String[] args)
    {
        // 1. Declare 3 int variables for grades and initialize them to 3 values
        // 2. Declare an int variable for the sum of the grades
        // 3. Declare a double variable for the average of the grades
        // 4. Write a formula to calculate the sum of the 3 grades
        // 5. Write a formula to calculate the average of the 3 grades from the
        //     sum using division and type casting.
        // 6. Print out the average
        // 7. Declare a double variable and calculate the variance
        // 8. Declare a double variable to compute the standard deviation.
    }
}
```


Lab 2

Use the following template(or something similar) to write a program that gives exact change with the least number of coins for a given number of cents. **Use intermediate variables to help your calculation.**

```
public static void main(String[] args){  
    int totalCents = 137; //137 can be any number  
    .....  
    // your code here.  
  
}
```

Output: 5 quarters, 1 dimes, 0 nickels, 2 pennies.

References

1) Building Java Programs: A Back to Basics Approach by Stuart Reges and Marty Stepp

2) Runestone CSAwesome Curriculum:

<https://runestone.academy/runestone/books/published/csawesome/index.html>

For more tutorials/lecture notes in Java, Python, game programming, artificial intelligence with neural networks:

<https://longbaonguyen.github.io>