COMP30820
Java Programming (Conv)

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Chapter 2 Elementary Programming

Objectives

- To write Java programs to perform simple computations (§2.2).
- To obtain input from the console using the **Scanner** class (§2.3).
- To use identifiers to name variables, constants, methods, and classes (§2.4).
- To use variables to store data (§§2.5–2.6).
- To program with assignment statements (§2.6).
- To use constants to store permanent data (§2.7).
- To name classes, variables, and constants by following their naming conventions (§2.8).
- To explore Java numeric primitive data types: **byte**, **short**, **int**, **long**, **float**, and **double** (§2.9.1).
- To perform operations using operators +, **-**, *****, /, and **%** (§2.9.3).
- To perform exponent operations using **Math.pow(a, b)** (§2.9.4).
- To write and evaluate numeric expressions (§2.11).
- To use augmented assignment operators (§2.13).
- To distinguish between postincrement and preincrement and between postdecrement and predecrement (§2.14).
- To cast the value of one type to another type (§2.15).

Identifiers

- Identifiers are the names that identify the elements (classes, methods, variables) in a program.
- An identifier is a sequence of characters that consist of letters, digits, underscores (_), and dollar signs (`$`).
- An identifier must start with a letter, an underscore (_), or a dollar sign (`$`) – it cannot start with a digit.
- An identifier cannot be a reserved word (e.g. `int`, `for`, `if`, `else`, `class`…). See Appendix A in textbook, "Java Keywords," for a list of reserved words.
- An identifier cannot be `true`, `false`, or `null`.
- An identifier can be of any length.

Declaring Variables

Variables are used to represent values that may be changed in a program

In Java variables have types (!)

```
int x;          // Declare x to be an integer variable

double radius; // Declare radius to be a double variable

char ch;        // Declare ch to be a character variable
```

Assignment Statements

```
x = 1;           // Assign 1 to x;

radius = 1.0;    // Assign 1.0 to radius;

ch = 'A';        // Assign 'A' to ch;
```

Declaring and Initializing in One Step

```
int x = 1;

double radius = 1.0;

char ch = 'A';
```

Assignment Statements

An *assignment statement* designates a value for a variable

The *assignment operator* is the equal sign (=)

The syntax for assignment statements is:

```
variable = expression;
```

An *expression* represents a computation involving values, variables and operators that taken together evaluates to a value:

```
double radius = 5.0;
double area = radius * radius * 3.14159;
```

Numerical Data Types

Name	*Range*	*Storage Size*
`byte`	-2^7 to $2^7 - 1$ (−128 to 127)	8-bit signed
`short`	-2^{15} to $2^{15} - 1$ (−32768 to 32767)	16-bit signed
`int`	-2^{31} to $2^{31} - 1$ (−2147483648 to 2147483647)	32-bit signed
`long`	-2^{63} to $2^{63} - 1$	64-bit signed
	(i.e., −9223372036854775808 to 9223372036854775807)	
`float`	Negative range: −3.4028235E + 38 to −1.4E − 45	32-bit IEEE 754
	Positive range: 1.4E − 45 to 3.4028235E + 38	
`double`	Negative range: −1.7976931348623157E + 308 to −4.9E − 324	64-bit IEEE 754
	Positive range: 4.9E − 324 to 1.7976931348623157E + 308	

Example Program

The following program computes the area of a circle and displays the result...

animation

Create/Trace a Program Execution

```
public class ComputeArea {




}
```

animation

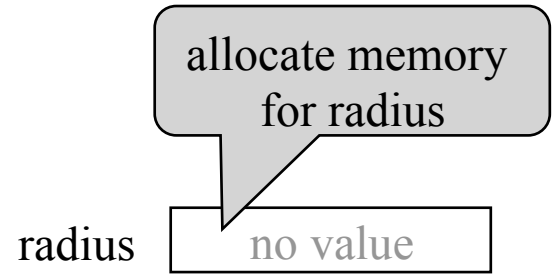
Create/Trace a Program Execution

```
public class ComputeArea {
  // main method
  public static void main(String[] args) {




  }
}
```

animation

Create/Trace a Program Execution

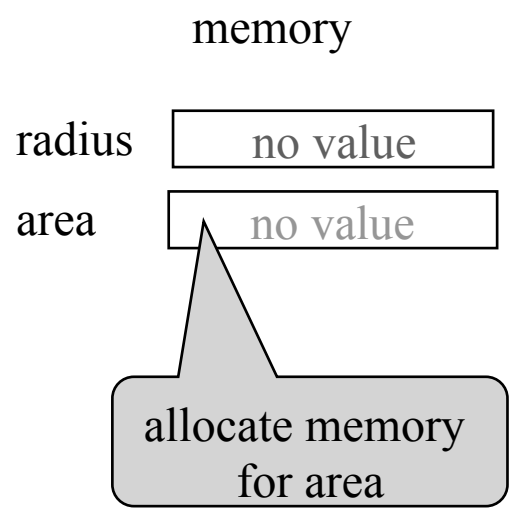
```
public class ComputeArea {
  // main method
  public static void main(String[] args) {
    double radius;


  }
}
```



animation

Create/Trace a Program Execution

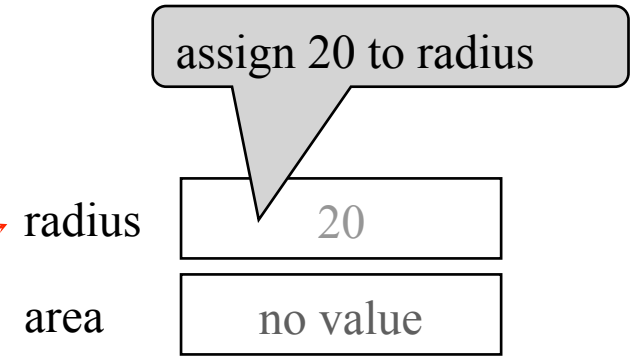
```
public class ComputeArea {
  // main method
  public static void main(String[] args) {
    double radius;
    double area;


  }
}
```



animation

Create/Trace a Program Execution

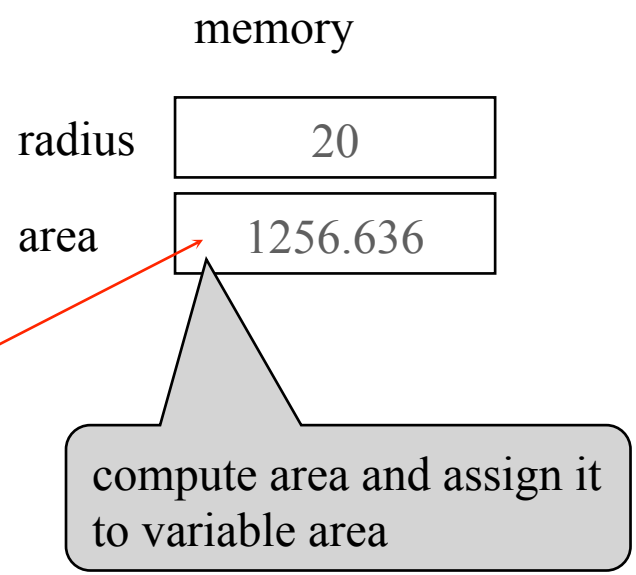
```
public class ComputeArea {
  // main method
  public static void main(String[] args) {
    double radius;
    double area;

    // Assign a radius
    radius = 20;


  }
}
```



animation

Create/Trace a Program Execution

```
public class ComputeArea {
  // main method
  public static void main(String[] args) {
    double radius;
    double area;

    // Assign a radius
    radius = 20;

    // Compute area
    area = radius * radius * 3.14159;



  }
}
```



animation

Create/Trace a Program Execution

```
public class ComputeArea {
  // main method
  public static void main(String[] args) {
    double radius;
    double area;

    // Assign a radius
    radius = 20;

    // Compute area
    area = radius * radius * 3.14159;

    // Display results
    System.out.println("The area of the circle of radius " + radius + " is " + area);
  }
}
```

memory

radius	20
area	1256.636

print a message to the console

The area of the circle of radius 20.0 is 1256.636

Number Literals

A *literal* is a constant value that appears directly in the program.

For example, 34 and 5.0 are literals in the following statements:

```
int i = 34;
double d = 5.0;
```

Integer Literals

An integer literal can be assigned to an integer variable as long as it can fit into the variable.

A compilation error would occur if the literal were too large for the variable to hold.

For example, the statement `byte b = 1000;` would cause a compilation error, because 1000 cannot be stored in a variable of the `byte` type (generally use `int` for integers).

Floating-Point Literals

Floating-point literals are written with a decimal point – for example: 5.0

Java has two numeric types for floating-point numbers – `float` and `double`:

```
float num = 1.0f; or float num = 1.0F;

double num = 1.0d; or double num = 1.0D;
```

By default, a floating-point literal is treated as a `double` type value:

```
double num = 1.0;
```

Use `double` type – values are more accurate than `float` type values:

```
System.out.println(1.0F / 3.0F); // prints 0.33333334

System.out.println(1.0 / 3.0);   // prints 0.3333333333333333
```

NOTE

Calculations involving floating-point numbers are approximated because these numbers *are not stored* with complete accuracy.

For example:

- `System.out.println(1.0 - 0.9);`

  displays 0.09999999999999998, not 0.1

- `System.out.println(1.0 – 0.1 - 0.1 - 0.1 - 0.1 - 0.1);`

  displays 0.5000000000000001, not 0.5

Integers *are stored* precisely – calculations with integers yield a precise integer result.

Named Constants

A named constant is a variable that represents a permanent value.

General form:

```
final datatype CONSTANTNAME = value;
```

Examples:

```
final double PI = 3.14159;
final int SIZE = 3;
```

Note – a final variable can only be initialized once.

Naming Conventions

- Choose meaningful and descriptive names.

- Variable names:
  - Use lowercase: e.g. `radius` and `area`.
  - If the name consists of several words, concatenate all in one, use lowercase for the first word, and capitalize the first letter of each subsequent word in the name: e.g. `interestRate`.

- Class names:
  - Capitalize the first letter of each word in the name: e.g. `Welcome` and `ComputeArea`.

- Constants:
  - Capitalize all letters in constants, and use underscores to connect words: e.g. `PI` and `MAX_VALUE`

Numeric Operators

Name	Meaning	Example	Result
+	Addition	34 + 1	35
-	Subtraction	34.0 - 0.1	33.9
*	Multiplication	300 * 30	9000
/	Division	1.0 / 2.0	0.5
%	Remainder	20 % 3	2

How to Evaluate an Expression

The value of a Java expression and its corresponding arithmetic expression are the same.

What is the value of the following expression?

```
3 + 4 * 4 + 5 * (4 + 3) - 1
```

How to Evaluate an Expression

```
3 + 4 * 4 + 5 * (4 + 3) - 1
```

How to Evaluate an Expression

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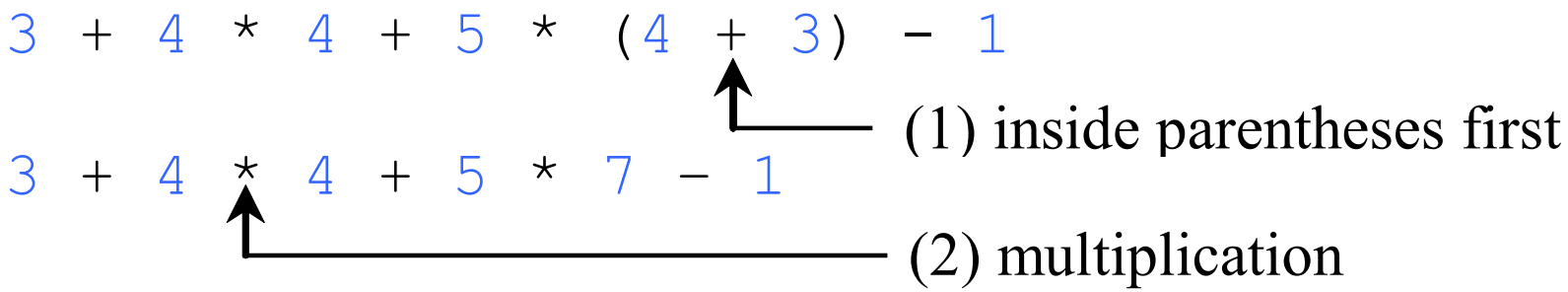
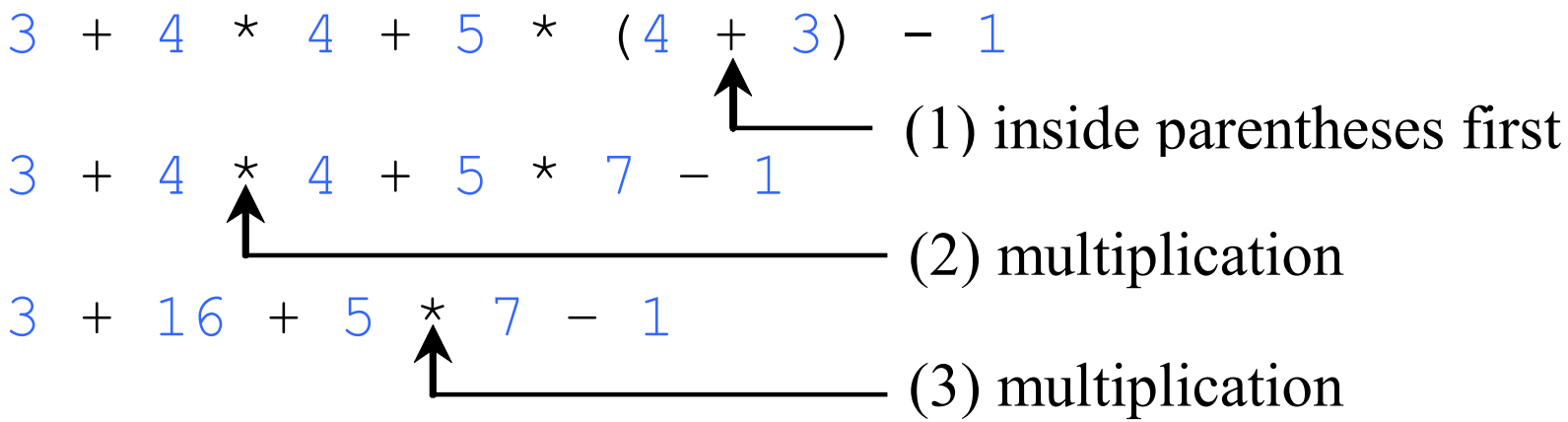
How to Evaluate an Expression



How to Evaluate an Expression



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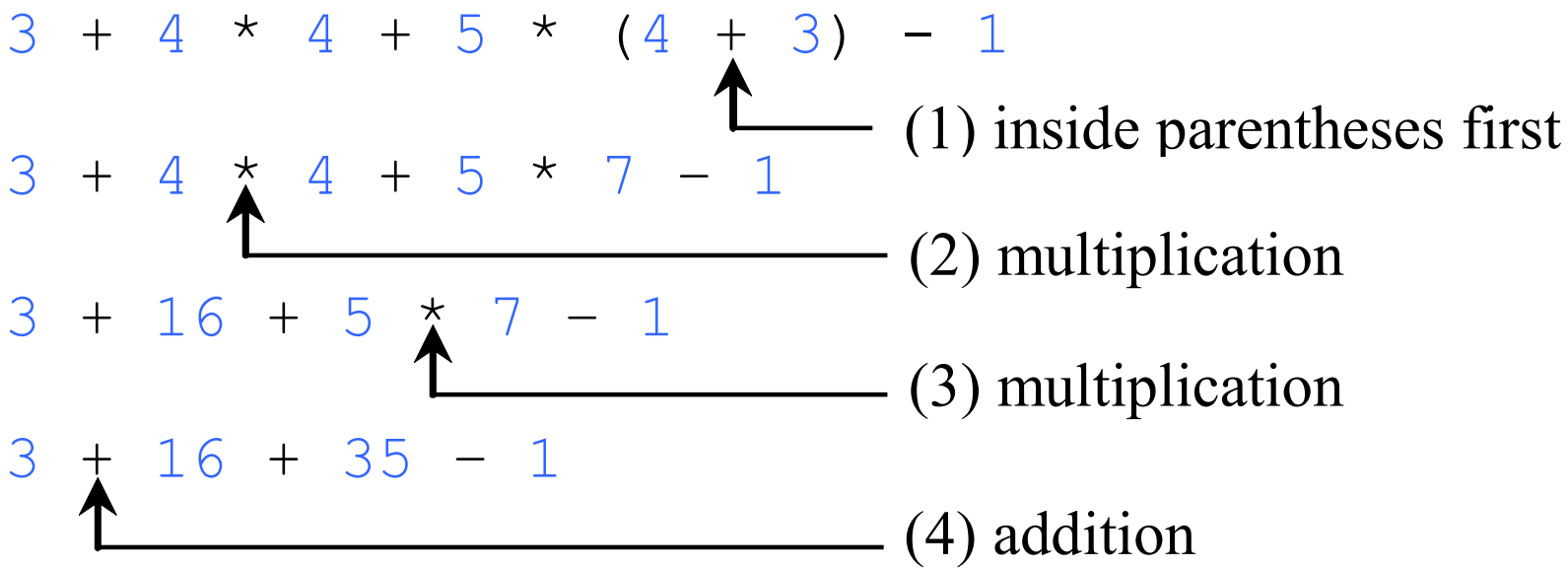

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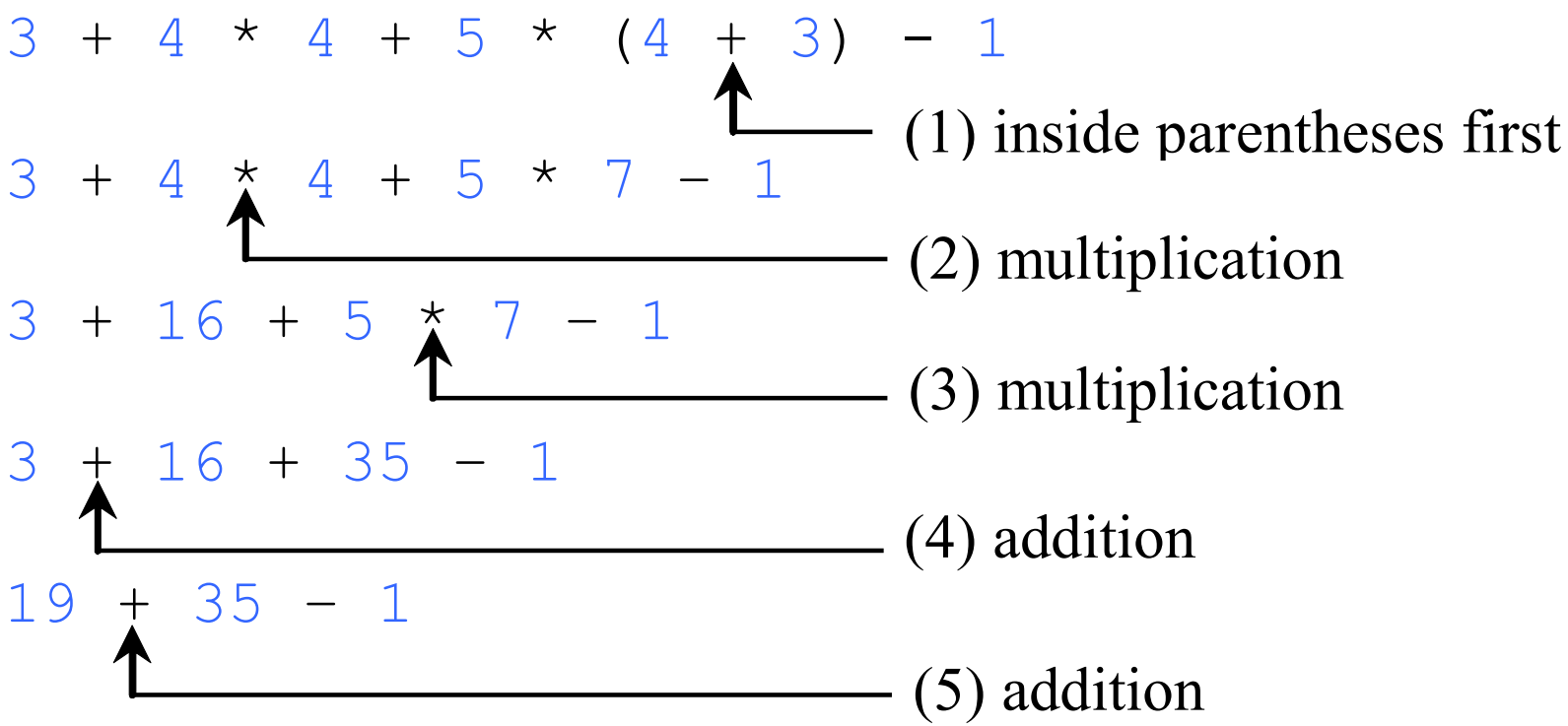

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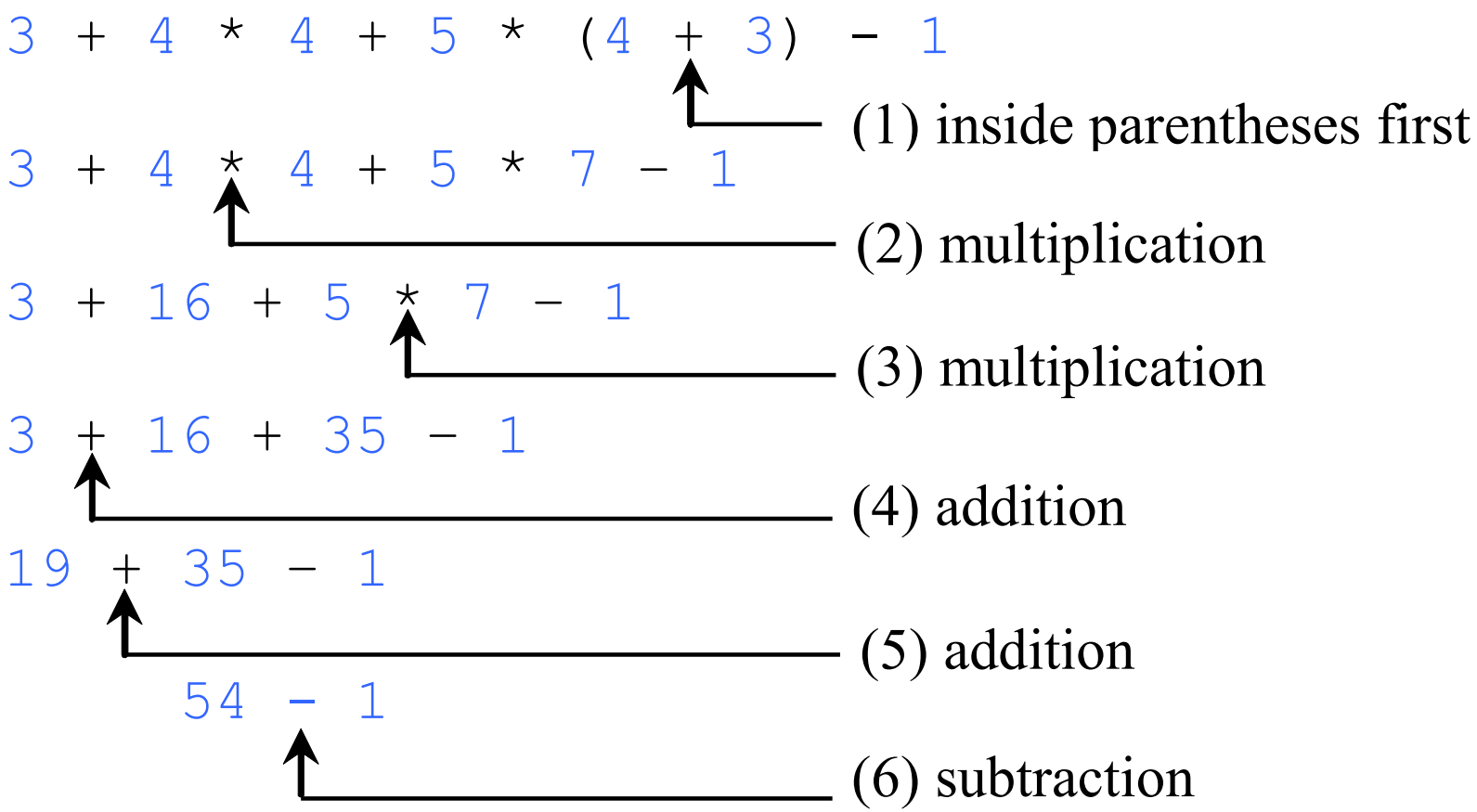

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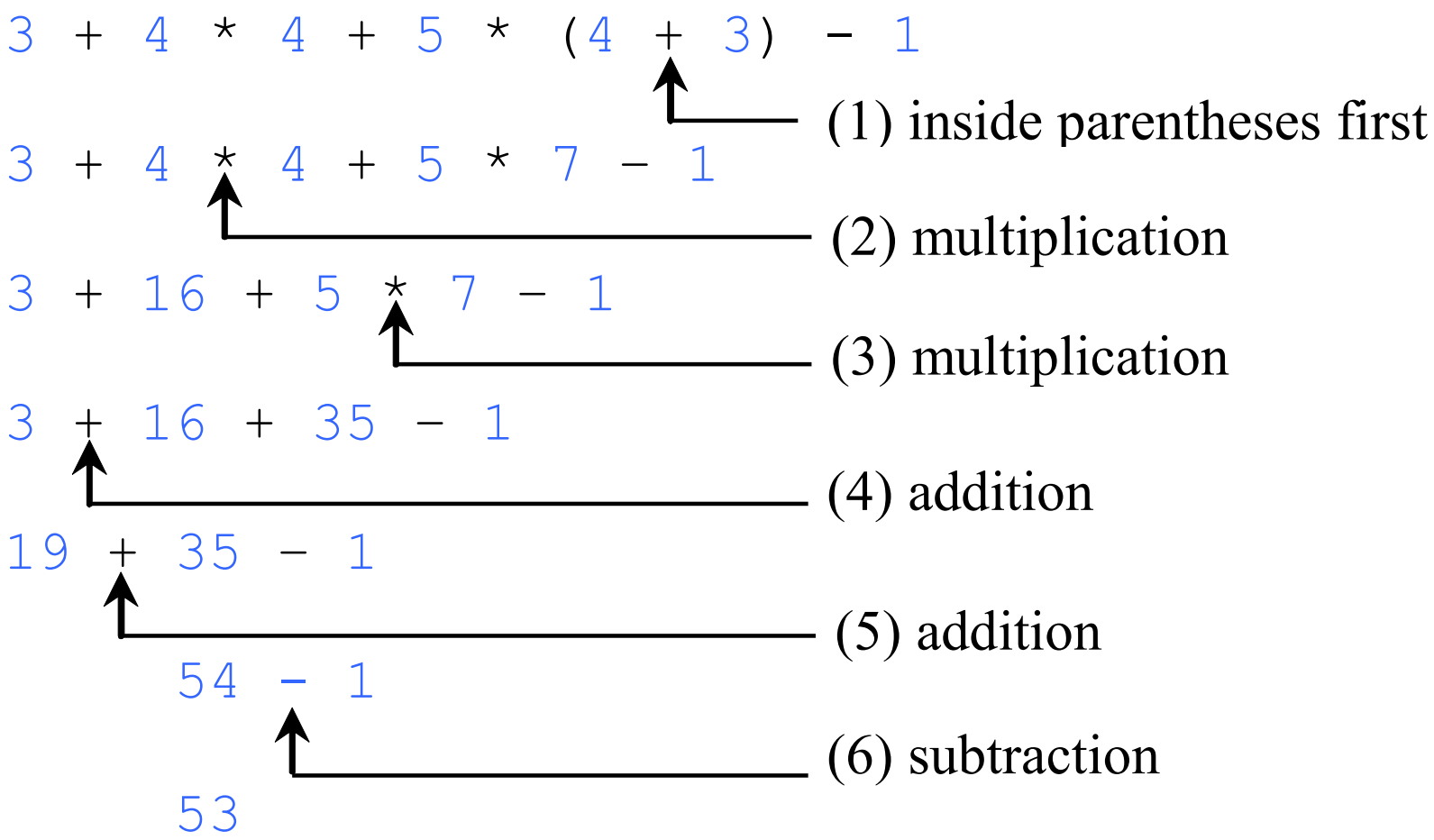

Arithmetic Expressions

Example – translate the following into a Java expression:

$$\frac{3 + 4x}{5} - \frac{10(y - 5)(a + b + c)}{x} + 9\left(\frac{4}{x} + \frac{9 + x}{y}\right)$$

Answer:

```
(3+4*x)/5 - 10*(y-5)*(a+b+c)/x + 9*(4/x + (9+x)/y)
```

Operator Precedence

When more than one operator is used in an expression, the following operator precedence rules are used to determine the order of evaluation:

- Multiplication, division, and remainder operators are applied first. If an expression contains several multiplication, division, and remainder operators, they are applied from left to right.
- Addition and subtraction operators are applied last. If an expression contains several addition and subtraction operators, they are applied from left to right.

Examples:

```
double d1 = 2.0 / 3 * 2;

double d2 = 2.0 * 3 / 2;
```

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- Addition and subtraction operators are applied last. If an expression contains several addition and subtraction operators, they are applied from left to right.

Examples:

```
double d1 = 2.0 / 3 * 2; // d1 is 1.3333333333333333

double d2 = 2.0 * 3 / 2; // d2 is 3.0
```

Type Casting

Casting is an operation that converts a value of one data type into a value of another data type.

Type widening refers to casting a type with a smaller range to a type with a larger range. Java automatically widens a type. For example:

```
double d = 3;
```

Type narrowing refers to casting a type with a larger range to a type with a smaller range. Must be done explicitly. For example:

```
int i = (int)3.9; // i is 3, fraction part is truncated
```

Numeric Type Conversion: Rules

When performing a binary operation involving two operands of different types (e.g. `x + y`), Java automatically converts operands based on the following rules:

1. If one of the operands is double, the other is converted into double.
2. Otherwise, if one of the operands is float, the other is converted into float.
3. Otherwise, if one of the operands is long, the other is converted into long.
4. Otherwise, both operands are converted into int.

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What is wrong? `int x = 5 / 2.0;`

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Fix #1:

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What is wrong?
```
int x = 5 / 2.0;
```
Fix #1:
```
int x = (int) (5 / 2.0);
```

Numeric Type Conversion: Rules

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4. Otherwise, both operands are converted into int.

What is wrong?

```
int x = 5 / 2.0;
```

Fix #1:

```
int x = (int) (5 / 2.0); // x = 2
```

Numeric Type Conversion: Rules

When performing a binary operation involving two operands of different types (e.g. `x + y`), Java automatically converts operands based on the following rules:

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3. Otherwise, if one of the operands is long, the other is converted into long.
4. Otherwise, both operands are converted into int.

What is wrong?
```
int x = 5 / 2.0;
```
Fix #1:
```
int x = (int) (5 / 2.0); // x = 2
```
Fix #2:

Numeric Type Conversion: Rules

When performing a binary operation involving two operands of different types (e.g. `x + y`), Java automatically converts operands based on the following rules:

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What is wrong?
```
int x = 5 / 2.0;
```
Fix #1:
```
int x = (int) (5 / 2.0); // x = 2
```
Fix #2:
```
double x = 5 / 2.0;
```

Numeric Type Conversion: Rules

When performing a binary operation involving two operands of different types (e.g. `x + y`), Java automatically converts operands based on the following rules:

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What is wrong?
```
int x = 5 / 2.0;
```
Fix #1:
```
int x = (int) (5 / 2.0); // x = 2
```
Fix #2:
```
double x = 5 / 2.0; // x = 2.5
```

Common Error: Unintended Integer Division

```
int n1 = 1;
int n2 = 2;
double average = (n1 + n2) / 2;
System.out.println(average);
```

Common Error: Unintended Integer Division

```
int n1 = 1;
int n2 = 2;
double average = (n1 + n2) / 2;
System.out.println(average);
```

Change line 3 as follows:

```
double average = (n1 + n2) / 2.0;
```

Augmented Assignment Operators

Operator	*Name*	*Example*	*Equivalent*
`+=`	Addition assignment	`i += 8`	`i = i + 8`
`-=`	Subtraction assignment	`i -= 8`	`i = i - 8`
`*=`	Multiplication assignment	`i *= 8`	`i = i * 8`
`/=`	Division assignment	`i /= 8`	`i = i / 8`
`%=`	Remainder assignment	`i %= 8`	`i = i % 8`

Increment and Decrement Operators

Operator	*Name*	*Description*	*Example (assume i = 1)*
`++var`	preincrement	Increment `var` by `1`, and use the new `var` value in the statement	`int j = ++i;` `// j is 2, i is 2`
`var++`	postincrement	Increment `var` by `1`, but use the original `var` value in the statement	`int j = i++;` `// j is 1, i is 2`
`--var`	predecrement	Decrement `var` by `1`, and use the new `var` value in the statement	`int j = --i;` `// j is 0, i is 0`
`var--`	postdecrement	Decrement `var` by `1`, and use the original `var` value in the statement	`int j = i--;` `// j is 1, i is 0`

Increment and Decrement Operators, cont.

```
int i = 10;
int newNum = 10 * ++i;
```

Same effect as

```
i = i + 1;
int newNum = 10 * i;
```

```
int i = 10;
int newNum = 10 * i++;
```

Same effect as

```
int newNum = 10 * i;
i = i + 1;
```

Increment and Decrement Operators, cont.

Using increment and decrement operators makes expressions short, but it also can make them complex and difficult to read.

Increment and Decrement Operators, cont.

Using increment and decrement operators makes expressions short, but it also can make them complex and difficult to read.

While the previous examples are fine, **avoid** using these operators in expressions that modify multiple variables, or the same variable multiple times such as this:

Increment and Decrement Operators, cont.

Using increment and decrement operators makes expressions short, but it also can make them complex and difficult to read.

While the previous examples are fine, **avoid** using these operators in expressions that modify multiple variables, or the same variable multiple times such as this:

```
int i = 1;
int k = ++i + i + i++;
```

What are the values of `i` and `k`??

Increment and Decrement Operators, cont.

Using increment and decrement operators makes expressions short, but it also can make them complex and difficult to read.

While the previous examples are fine, **avoid** using these operators in expressions that modify multiple variables, or the same variable multiple times such as this:

```
int i = 1;
int k = ++i + i + i++;
```

What are the values of `i` and `k`??

Answer: `i` is 3 and `k` is 6

Standard Input/Output

`System.out` refers to the standard output device (console)

- To perform console output, you simply use the `println` method; e.g.

```
System.out.println("Hello World!");
```

`System.in` refers to the standard input device (keyboard)

- Use the `Scanner` class to read input from `System.in`:

```
Scanner input = new Scanner(System.in);
```

- Then, to read e.g. a double value from the keyboard, invoke the `nextDouble()` method:

```
double d = input.nextDouble();
```

ComputeAverage

Reading Numbers from the Console

```
Scanner input = new Scanner(System.in);
int value = input.nextInt();
double d = input.nextDouble();
```

…

Method	Description
`nextByte()`	reads an integer of the `byte` type.
`nextShort()`	reads an integer of the `short` type.
`nextInt()`	reads an integer of the `int` type.
`nextLong()`	reads an integer of the `long` type.
`nextFloat()`	reads a number of the `float` type.
`nextDouble()`	reads a number of the `double` type.

See the Java API for more information –
https://docs.oracle.com/en/java/javase/11/docs/api/index.html

`Math` Class

The Java API contains the `Math` class – useful for performing common mathematical functions.

Use `Math.pow(a, b)` to compute a^b – for example:

```
double d = Math.pow(2, 3); // d is 8.0
double d = Math.pow(4, 0.5); // d is 2.0
double d = Math.pow(2.5, 2); // d = 6.25
double d = Math.pow(2, -2); // d = 0.25
```

The Math class also provides the constant PI:

```
double area = radius * radius * Math.PI;
double area = Math.pow(radius, 2) * Math.PI;
```

Compute the square root of a number as follows:

```
double d = 4.0;
double s = Math.sqrt(d); // s is 2.0
```

See the Java API for more information –
https://docs.oracle.com/en/java/javase/11/docs/api/index.html

Next Topics…

Chapter 3:

- `boolean` variables, relational operators, Boolean expressions
- `if-else` statements
- `switch` statements
- operator precedence