

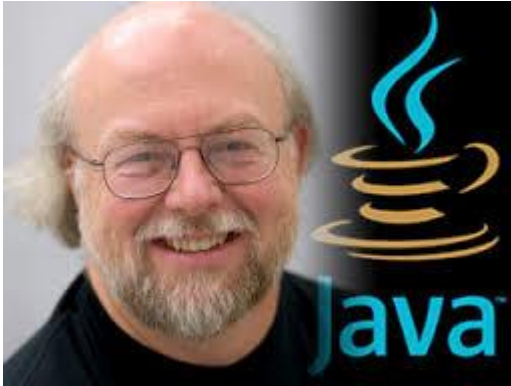
# Software Components

Introduction to Java



1. Java: Brief history and background
2. Run cycle
3. Basic program structure
4. Basic Java elements
  - 4.1 Arithmetic Expressions
  - 4.2 Control Flow Statements and Logical Expressions
  - 4.3 Basic Input (Scanner class) and Output
  - 4.4 API
  - 4.5 Math class, Class Attributes
  - 4.6 User-defined Functions

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James Gosling

1995, Sun Microsystems

Use C/C++ as foundation

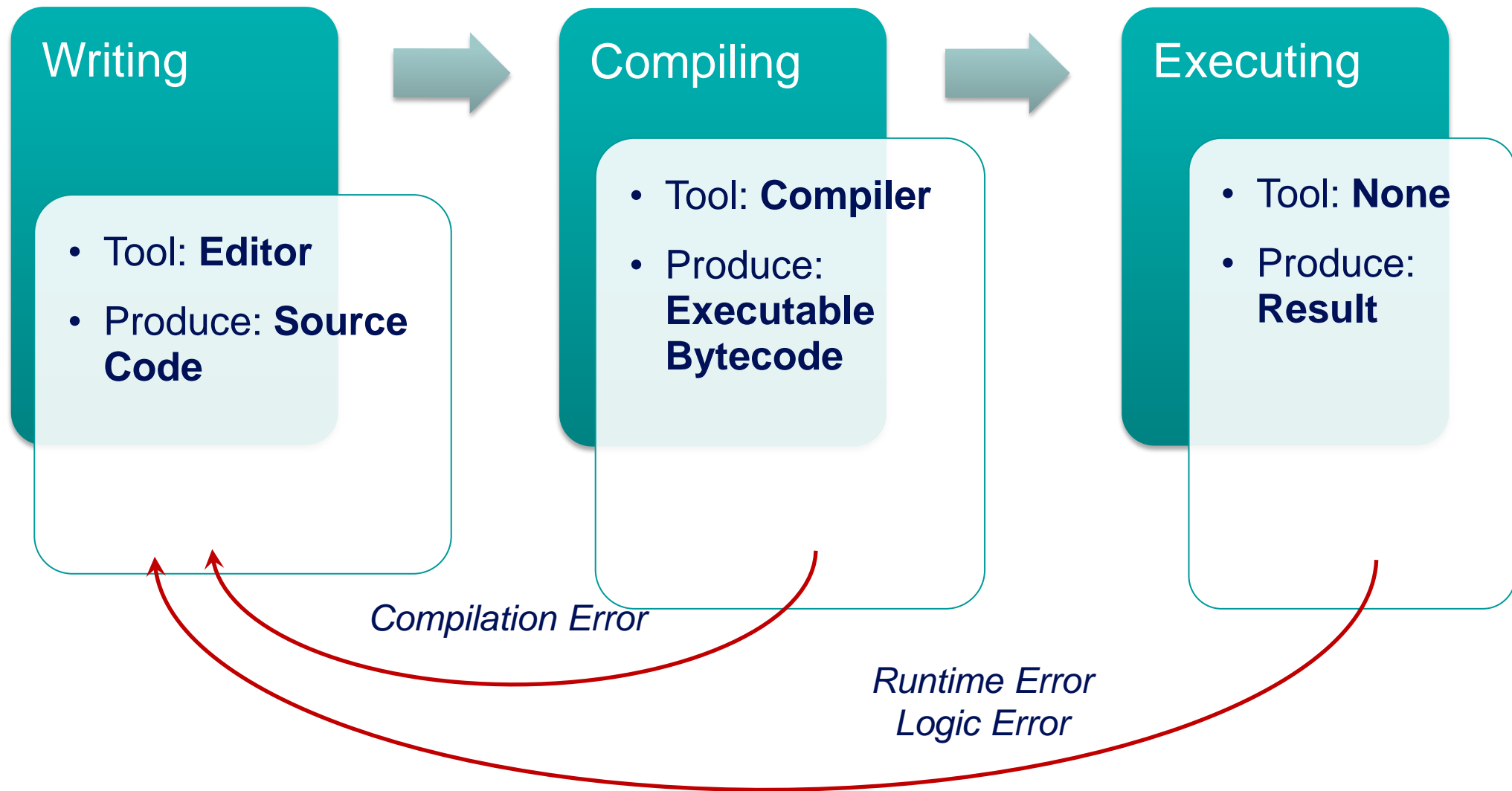
- “Cleaner” in syntax
- Less low-level machine interaction



- **Write Once, Run Everywhere™**
- Extensive and well documented standard library

- Less efficient

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### ■ Writing/Editing Program

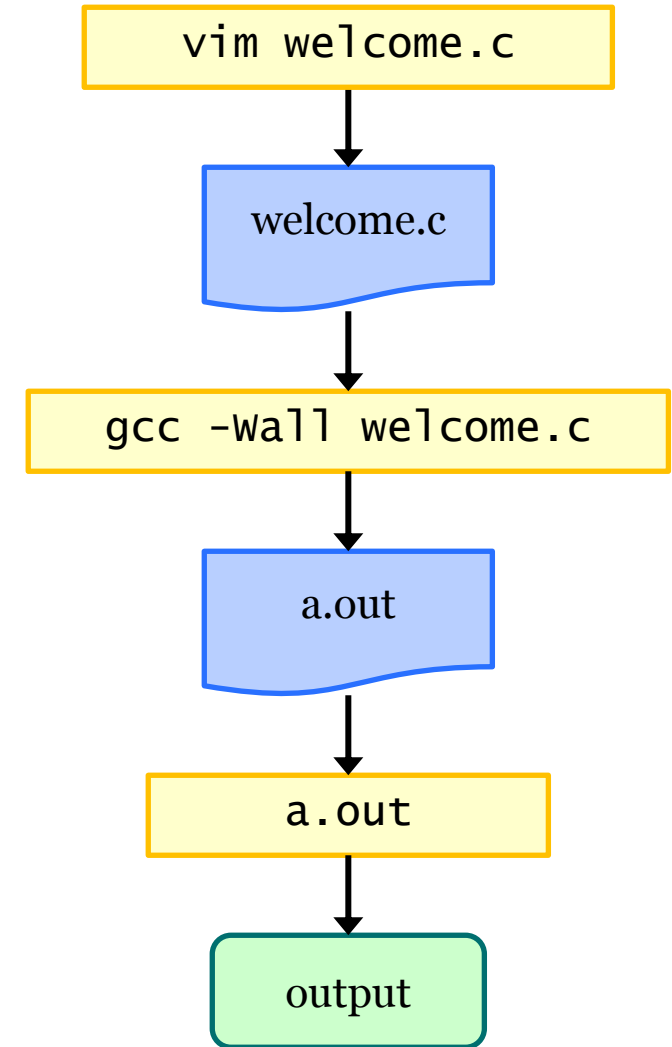
- Use an editor, e.g.: vim
- Source code must have a **.c** extension

### ■ Compiling Program

- Use a C compiler, eg: gcc
- Default executable file: **a.out**

### ■ Executing Binary

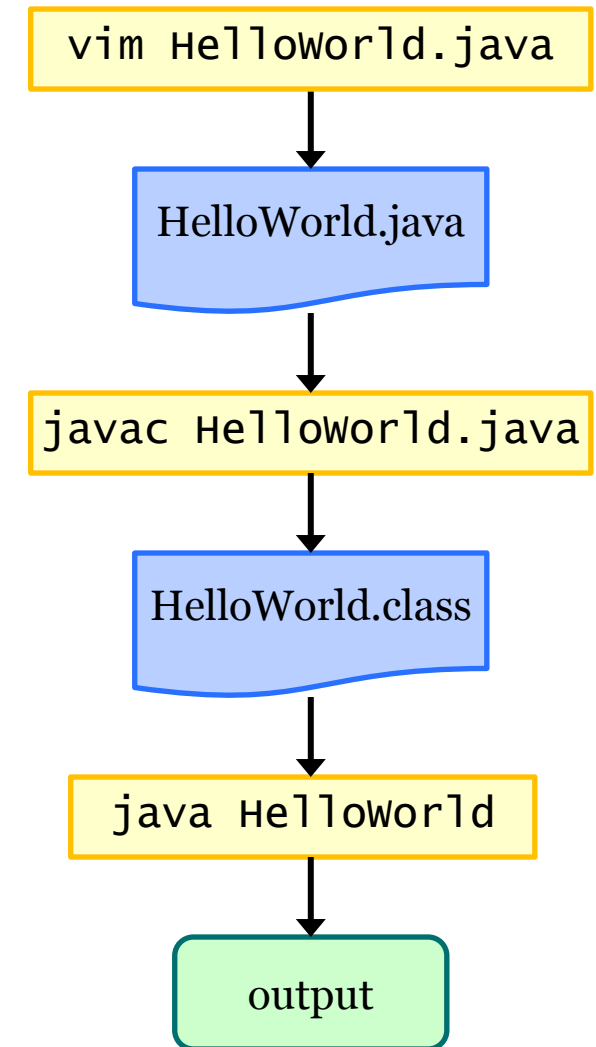
- Type name of executable file

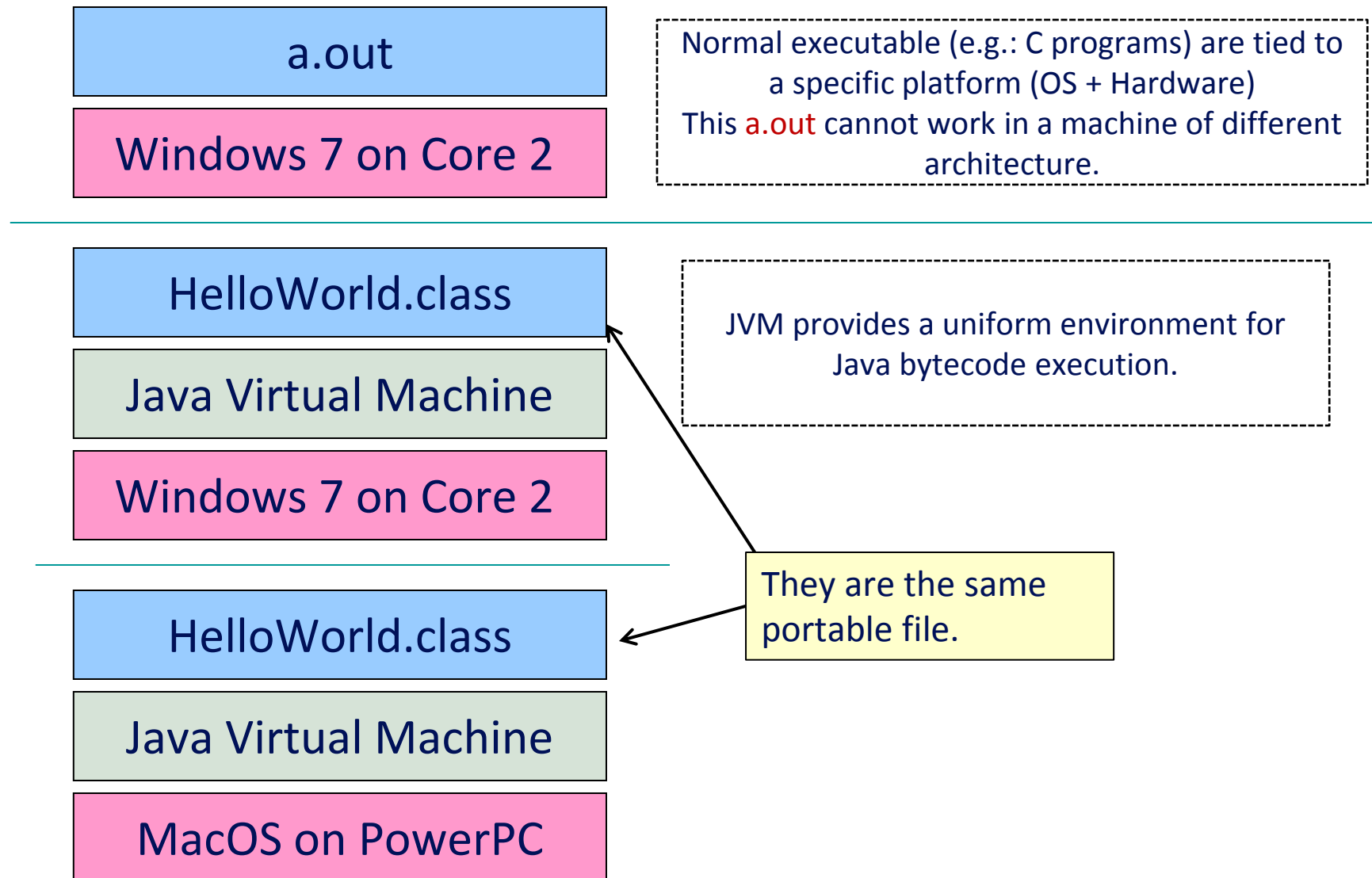


- Normal executable files are directly dependent on the OS/Hardware
  - Hence, an executable file is usually not executable on different platforms
  - E.g: The **a.out** file compiled on sunfire is not executable on your Windows computer
- Java overcomes this by running the executable on an **uniform hardware environment** simulated by software
  - The hardware environment is know as the **Java Virtual Machine (JVM)**
  - So, we only need a **specific JVM** for a particular platform to execute all Java bytecodes without recompilation



- **Writing/Editing Program**
  - Use an text editor, e.g: vim
  - Source code must have **.java** extension
- **Compiling Program**
  - Use a Java compiler, e.g.: **javac**
  - Compiled binary has **.class** extension
  - The binary is also known as **Java Executable Bytecode**
- **Executing Binary**
  - Run on a **Java Virtual Machine (JVM)**
    - e.g.: **java HelloWorld**  
(leave out the **.class** extension)
  - Note the difference here compared to C executable





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- Today: just the basic language components:
  - Basic Program Structure
  - Primitive data types and simple variables
  - Control flow (selection and repetition statements)
  - Input/output statements
- Purpose: ease you into the language
  - You can attempt to “translate” some simple C into Java
- We will gradually cover many other Java features over the next few weeks

C

```
#include <stdio.h>

int main(void) {
    printf("Hello World!\n");

    return 0;
}
```

HelloWorld.c

Java

```
import java.lang.*; // optional

public class HelloWorld {

    public static void main(String[] args) {
        System.out.println("Hello World!");
    }
}
```

HelloWorld.java

*Beginners' common mistake:*  
Public class name not identical to program's file name.

- Library in Java is known as **package**
  - Packages are organized into hierarchical grouping
  - E.g., the “**System.out.println()**” is defined in the “**java.lang.System**”
    - i.e. “**lang**” (language) is a package under “**java**” (the main category) and “**System**” is a class under “**lang**”
- To use a predefined library, the appropriate package should be **imported**:
  - Using the “**import** **XXXXXX**;” statement
  - All packages under a group can be imported with a “**\***” (the wildcard character)
- Packages under “**java.lang**” are imported **by default**
  - Hence, the **import** statement in this example is optional

- The main() method (function) is now enclosed in a “**class**”
  - More about class will be explained in lecture 2
  - There should be only one **main()** method in a program, which serves as the execution starting point
  - A source code file may contain **one or more classes**
    - There are restrictions which will be explained later – this is a bit too advanced at this point
    - For the moment, we will restrict ourselves to one class per source code
  - Each class will be compiled into a separate **XXXX.class** **bytecode**
    - The “**XXXX**” is taken from the class name (“**HelloWorld**” in this example)

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- **Identifier** is a **name** that we associate with some program entity (class name, variable name, parameter name, etc.)
- Java Identifier Rule:
  - May consist of letters ('a' – 'z', 'A' – 'Z'), digit characters ('0' – '9'), underscore () and dollar sign (\$)
  - Cannot begin with a digit character
- **Variable** is used to store data in a program
  - A variable must be declared with a specific data type
  - Eg: 

```
int countDays;  
double priceOfItem;
```

- **Constant** is used to represent a fixed value
  - Eg: 

```
public static final int PASSING_MARK = 65;
```
  - Keyword **final** indicates that the value cannot change
- Guidelines on how to name classes, variables, and constants: see website
  - <https://google.github.io/styleguide/javaguide.html>
  - Class name: UpperCamelCase
    - Eg: **Math**, **HelloWorld**, **ConvexGeometricShape**
  - Variable name: LowerCamelCase
    - Eg: **countDays**, **innerDiameter**, **numOfCoins**
  - Constant: All uppercase with underscore
    - Eg: **PI**, **CONVERSION\_RATE**, **CM\_PER\_INCH**

- Summary of numeric data types in Java:

Integer Data Types	Type Name	Size (#bytes)	Range
	byte	1	$-2^7$ to $2^7-1$
	short	2	$-2^{15}$ to $2^{15}-1$
	int	4	$-2^{31}$ to $2^{31}-1$
	long	8	$-2^{63}$ to $2^{63}-1$
	float	4	Negative: $-3.4028235E+38$ to $-1.4E-45$ Positive: $1.4E-45$ to $3.4028235E+38$
	double	8	Negative: $-1.7976931348623157E+308$ to $-4.9E-324$ Positive: $4.9E-324$ to $1.7976931348623157E+308$

- Unless otherwise stated, you are to use:
  - int for integers
  - double for floating-point numbers

↑ Higher Precedence	()	Parentheses Grouping	Left-to-right
	++, --	Postfix incrementor/decrementor	Right-to-left
	++, -- +, -	Prefix incrementor/decrementor Unary +, -	Right-to-left
	*, /, %	Multiplication, Division, Remainder of division	Left-to-right
	+, -	Addition, Subtraction	Left-to-right
	=	Assignment Operator	Right-to-left
	+= -= *= /= %=	Shorthand Operators	

#### ■ Evaluation of numeric expression:

- Determine grouping using precedence
- Use associativity to differentiate operators of same precedence
- Data type conversion is performed for operands with different data type

- When operands of an operation have differing types:
  1. If one of the operands is **double**, convert the other to **double**
  2. Otherwise, if one of them is **float**, convert the other to **float**
  3. Otherwise, if one of them is **long**, convert the other to **long**
  4. Otherwise, convert both into **int**
- When value is assigned to a variable of differing types:
  - **Widening (Promotion):**
    - Value has a smaller range compared to the variable
    - Converted automatically
  - **Narrowing (Demotion):**
    - Value has a **larger range** compared to the variable
    - **Explicit type casting** is needed

### ■ Conversion mistake:

```
double d;  
int i;  
  
i = 31415;  
d = i / 10000;
```

Q: What is assigned to **d**?

What's the mistake? How do you correct it?

### ■ Type casting:

```
double d;  
int i;  
  
d = 3.14159;  
i = (int) d; // i is assigned 3
```

Q: What is assigned to **i** if **d** contains 3.987 instead?

The **(int) d** expression is known as **type casting**

**Syntax:**

**(datatype) value**

**Effect:**

**value** is converted explicitly to the data type stated if possible.

- Write a simple Java program `Temperature.java`:
  - To convert a temperature reading in Fahrenheit, a real number, to Celsius degree using the following formula:

$$celsius = \frac{5}{9} \times (fahrenheit - 32)$$

- Print out the result
- For the time being, you can hard code a value for the temperature in Fahrenheit instead of reading it from user

## Temperature.java

```
public class Temperature {  
    public static void main(String[] args) {  
        double fahrenheit = 123.5;  
        double celsius = (5.0/9) * (fahrenheit - 32);  
        System.out.println("Celsius: " + celsius);  
    }  
}
```

Output:

Celsius: 50.833333333333336

Compare with C:

```
printf("Celsius: %f\n", celsius);
```

## ■ Notes:

- **5.0/9** is necessary to get the correct result (what will 5/9 give?)
- “+” in the printing statement
  - Concatenate operator, to combine strings into a single string
  - Variable values will be converted to string automatically
- There is another printing statement, **System.out.print()**, which does not include newline at the end of line (more in section 4.3)



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# Program Execution Flow

- Java provides an actual **boolean** data type
  - Store boolean value **true** or **false**, which are keywords in Java
  - Boolean expression evaluates to either **true** or **false**

SYNTAX	<code>boolean variable;</code>
Example	<pre>boolean isEven; int input; <i>// code to read input from user omitted</i> if (input % 2 == 0)     isEven = true; else     isEven = false; if (isEven)     System.out.println("Input is even!");</pre> <div>Equivalent: <code>isEven = (input % 2 == 0);</code></div>

	Operators	Description
Relational Operators	<	less than
	>	larger than
	<=	less than or equal
	>=	larger than or equal
	==	Equal
	!=	not equal
Logical Operators	&&	and
		or
	!	not
	^	exclusive-or

Operands are variables / values that can be compared directly.

Examples:

`X < Y`

`1 >= 4`

Operands are boolean variables/expressions.

Examples:

`(X < Y) && (Y < Z)`

`(!isEven)`

- In ANSI C, there is no boolean type.
  - Zero means 'false' and any other value means 'true'

```
int x;
... // assume x is assigned a non-negative value
if (x % 3) {
    printf("%d is not divisible by 3.\n", x);
} else {
    printf("%d is divisible by 3.\n", x);
}
```

- 
- In Java, the above is invalid
  - Java code:

```
int x;
... // assume x is assigned a non-negative value
if ((x % 3) != 0) {
    System.out.println(x + " is not divisible by 3.");
} else {
    System.out.println(x + " is divisible by 3.");
}
```

```
if (a > b) {  
    ...  
} else {  
    ...  
}
```

- **if-else** statement
  - else-part is optional
- Condition:
  - Must be a *boolean* expression
  - **Unlike C, integer values are NOT valid**

```
switch (a) {  
    case 1:  
        ...  
        break;  
    case 2:  
    case 3:  
        ...  
    default:  
}
```

- **switch-case** statement
- Expression in **switch()** must evaluate to a value of **char**, **byte**, **short** or **int** type
- **break**: stop the fall-through execution
- **default**: catch all unmatched cases; may be optional

```
while (a > b) {  
    ... //body  
}
```

```
do {  
    ... //body  
} while (a > b);
```

```
for (A; B; C) {  
    ... //body  
}
```

- Valid conditions:
    - Must be a *boolean* expression
  - **while** : check condition before executing body
  - **do-while**: execute body before condition checking
- 
- **A**: initialization (e.g. `i = 0`)
  - **B**: condition (e.g. `i < 10`)
  - **C**: update (e.g. `i++`)
  - Any of the above can be empty
  - Execution order:
    - **A**, **B**, **body**, **C**, **B**, **body**, **C**, ...

- In ANSI C, the loop variable must be declared before it is used in a **'for'** loop

```
int i;  
for (i = 0; i < 10; i++) {  
    ...  
}
```

- In Java, the loop variable may be declared in the initialisation part of the **'for'** loop
- In example below, the scope of variable **i** is within the **'for'** loop only

```
for (int i = 0; i < 10; i++) {  
    ...  
}
```



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Interacting with the outside world

PACKAGE	<pre>import java.util.Scanner;</pre>
SYNTAX	<pre><i>//Declaration of Scanner "variable"</i> Scanner scVar = new Scanner(System.in);  <i>//Functionality provided</i> scVar.nextInt();  scVar.nextDouble();  .....</pre> <div>Read an integer value from source System.in</div> <div>Read a double value from source System.in</div> <div>Other data types, to be covered later</div>

## TemperatureInteractive.java

```
import java.util.Scanner; // or import java.util.*;

public class TemperatureInteractive {

    public static void main(String[] args) {

        Scanner sc = new Scanner(System.in);

        System.out.print("Enter temperature in Fahrenheit: ");
        double fahrenheit = sc.nextDouble();

        double celsius = (5.0/9) * (fahrenheit - 32);
        System.out.println("Celsius: " + celsius);

    }
}
```

## ■ The statement

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

- Declares a variable “sc” of **Scanner** type
- The initialization “**new Scanner**(**System.in**)”
  - Constructs a **Scanner** object
    - We will discuss more about object later
  - Attaches it to the standard input “**System.in**” (which is the keyboard)
    - This Scanner object **sc** will receive input from this source
  - Scanner can attach to a variety of input sources; this is just a typical usage

- After proper initialization, a Scanner object provides functionality to read value of various types from the input source

- The statement

```
fahrenheit = sc.nextDouble();
```

- *nextDouble()* works like a function (called **method** in Java) that returns a double value read interactively
- The Scanner object **sc** converts the input into the appropriate data type and returns it
  - in this case, user input from the keyboard is converted into a double value

- Typically, only one Scanner object is needed, even if many input values are to be read.
  - The same Scanner object can be used to call the relevant methods to read input values

Note

In CodeCrunch, your program will **NOT** work if you use more than one Scanner object with **System.in** as input stream.

- **System.out** is the predefined output device
  - Refers to the monitor/screen of your computer

## SYNTAX

```
//Functionality provided  
System.out.print( output_string );  
  
System.out.println( output_string );  
  
System.out.printf( format_string, [items] );
```

```
System.out.print("ABC");  
System.out.println("DEF");  
System.out.println("GHI");
```

```
System.out.printf("Very C-like %.3f\n", 3.14159);
```

*Output:*

```
ABCDEF  
GHI  
Very C-like 3.142
```



- Java introduces **printf()** in Java 1.5
  - Very similar to the C version
- The format string contains normal characters and a number of specifiers
  - Specifier starts with a percent sign (%)
  - Value of the appropriate type must be supplied for each specifier
- Common specifiers and modifiers:

%d	for integer value
%f	for double floating-point value
%s	for string
%b	for boolean value
%c	for character value

SYNTAX

**%[-][W].[P]type**

-: For left alignment

**W**: For width**P**: For precision

- One way to calculate the PI ( $\pi$ ) constant:

$$\pi = \frac{4}{1} - \frac{4}{3} + \frac{4}{5} - \frac{4}{7} + \frac{4}{9} - \dots\dots\dots$$

- Write `ApproximatePI.java` to:
  1. Ask the user for the `number of terms` to use for approximation
  2. Calculate  $\pi$  with the given number of terms
  3. Output the approximation in 6 decimal places

## ApproximatePI.java

```
import java.util.*; // using * in import statement

public class ApproximatePI {

    public static void main(String[] args) {
        Scanner sc = new Scanner(System.in);

        System.out.print("Enter number of terms: ");
        int nTerms = sc.nextInt();

        int sign = 1;
        int denom = 1;
        for (int i = 0; i < nTerms; i++) {
            pi += 4.0 / denom * sign;
            sign *= -1;
            denom += 2;
        }
        System.out.printf("PI = %.6f\n", pi);
    }
}
```

$$\pi = \frac{4}{1} - \frac{4}{3} + \frac{4}{5} - \frac{4}{7} + \frac{4}{9} - \dots$$

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# Application Programming Interface

- The **Scanner** class you have seen is part of the Java API
  - **API**: an interface for other programs to interact with a program without having direct access to the internal data of the program
  - Documentation, SE7: <http://docs.oracle.com/javase/7/docs/api/>
  - For Java programmers, it is **very important** to refer to the API documentation regularly!
- The API consists of many classes
  - You do not need to know all the classes (there are easily a few thousand classes altogether!)
  - You will learn some more classes in this course
- This week reading assignment
  - Read up **Scanner** class in the API documentation



The screenshot shows the Java Platform Standard Ed. 7 API documentation for the `Class Scanner` class. The browser address bar shows `docs.oracle.com/javase/7/docs/api/`. The left sidebar lists packages and classes, with `Scanner` selected. The main content area displays the class name, its inheritance hierarchy, implemented interfaces, and a code example.

Java™ Platform  
Standard Ed. 7

All Classes

Packages

- java.applet
- java.awt
- java.awt.color
- java.awt.datatransfer
- java.awt.dnd

Classes

- SAXParseException
- SAXParser
- SAXParserFactory
- SAXResult
- SAXSource
- SAXTransformerFactory
- Scanner
- ScatteringByteChannel
- ScheduledExecutorService
- ScheduledFuture
- ScheduledThreadPoolExecutor
- Schema
- SchemaFactory
- SchemaFactoryLoader
- SchemaOutputResolver
- SchemaViolationException
- ScriptContext
- ScriptEngine

Overview Package **Class** Use Tree Deprecated Index Help

Prev Class Next Class Frames No Frames

Summary: Nested | Field | Constr | Method Detail: Field | Constr | Method

java.util

## Class Scanner

java.lang.Object  
java.util.Scanner

All Implemented Interfaces:

Closeable, AutoCloseable, Iterator<String>

---

```
public final class Scanner
extends Object
implements Iterator<String>, Closeable
```

A simple text scanner which can parse primitive types and strings using regular expressions.

A `Scanner` breaks its input into tokens using a delimiter pattern, which by default matches whitespace. The rest of the class provides methods for scanning the input.

For example, this code allows a user to read a number from `System.in`:

```
Scanner sc = new Scanner(System.in);
int i = sc.nextInt();
```

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## Using the Math class

- From the API documentation

All Classes

## Packages

- java.applet
- java.awt
- java.awt.color
- java.awt.datatransfer
- java.awt.dnd
- java.awt.event
- java.awt.font

---

MarShaller  
Marshaller.Listener  
MaskFormatter  
Matcher  
MatchResult  
Math  
MathContext  
MatteBorder  
MBeanAttributeInfo  
MBeanConstructorInfo  
MBeanException  
MBeanFeatureInfo  
MBeanInfo  
MBeanNotificationInfo  
MBeanOperationInfo  
MBeanParameterInfo  
MBeanPermission  
MBeanRegistration  
MBeanRegistrationException  
MBeanServer  
MBeanServerBuilder  
MBeanServerConnection  
MBeanServerDelegate  
MBeanServerDelegateMBean

Modifier and Type	Field and Description
static double	<b>E</b> The double value that is closer than any other to <i>e</i> , the base of the natural logarithms.
static double	<b>PI</b> The double value that is closer than any other to <i>pi</i> , the ratio of the circumference of a circle to its diameter.

## Method Summary

Methods	
Modifier and Type	Method and Description
static double	<b>abs</b> (double a) Returns the absolute value of a double value.
static float	<b>abs</b> (float a) Returns the absolute value of a float value.
static int	<b>abs</b> (int a) Returns the absolute value of an int value.
static long	<b>abs</b> (long a) Returns the absolute value of a long value.
static double	<b>acos</b> (double a) Returns the arc cosine of a value; the returned angle is in the range 0.0 through $\pi$ .
static double	<b>asin</b> (double a) Returns the arc sine of a value; the returned angle is in the range $-\pi/2$ through $\pi/2$ .
static double	<b>atan</b> (double a) Returns the arc tangent of a value; the returned angle is in the range $-\pi/2$ through $\pi/2$ .

- Package: java.lang (default)
- Some useful **Math** methods:
  - `abs()`
  - `ceil()`
  - `floor()`
  - `max()`
  - `min()`
  - `pow()`
  - `random()`
  - `sqrt()`

- The **Math** class has two **class attributes**

<code>static double</code>	<b>E</b> The double value that is closer than any other to <i>e</i> , the base of the natural logarithms.
<code>static double</code>	<b>PI</b> The double value that is closer than any other to <i>pi</i> , the ratio of the circumference of a circle to its diameter.

- A **class attribute** (or **class member**) is associated with the class, not the individual instances (objects). Every instance of a class shares the class attribute.
  - We will explain about “objects” later.
- How to use it?
  - Example:  

```
double area = Math.PI * Math.pow(radius,2);
```
  - Here, **Math.PI** is used as the constant  $\pi$

## TestMath.java

```
// To find the area of the largest circle inscribed
// inside a square, given the area of the square.
import java.util.*;

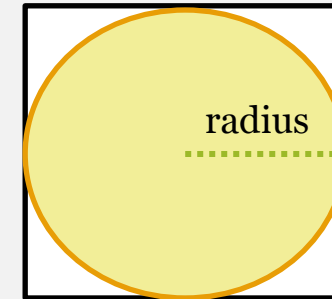
public class TestMath {

    public static void main(String[] args) {
        Scanner sc = new Scanner(System.in);

        System.out.print("Enter area of a square: ");
        double areaSquare = sc.nextDouble();

        double radius = Math.sqrt(areaSquare)/2;
        double areaCircle = Math.PI * Math.pow(radius, 2);

        System.out.printf("Area of circle = %.4f\n", areaCircle);
    }
}
```



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  - 4.6 User-defined Functions**

Reusable and independent code units

- In Java, C-like function is known as **static/class method**
  - Denoted by the “**static**” keyword before return data type
  - Another type of method, known as **instance method** will be covered later

### Factorial.java

```
public class Factorial {  
    // Pre-cond: n >= 0, Returns n!  
    public static int factorial (int n) {  
        if (n == 0) {  
            return 1;  
        } else {  
            return n * factorial(n-1);  
        }  
    }  
  
    public static void main(String[] args) {  
        int n = 5; // You can change it to interactive input  
        System.out.printf("Factorial(%d) = %d\n", n, factorial(n));  
    }  
}
```

If  $n$  is too big, say 40,  
what will happen? Why?

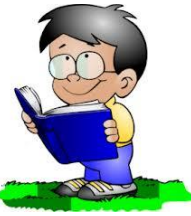


- All parameters in Java are **passed by value** (as in C):
  - A copy of the actual argument is created upon method invocation
  - The method parameter and its corresponding actual parameter are two independent variables
- In order to let a method modify the actual argument:
  - An **object reference data type** is needed (similar to pointer in C)
  - Will be covered later

*Data Types:**- Numeric Data Types:**byte, short, int, float, double**- Boolean Data Type:**boolean**Expressions:**- Arithmetic Expression**- Boolean Expression**Control Flow Statements:**- Selection Statements: if-else, switch-case**- Repetition Statements: while, do-while, for**Classes:**- Scanner**- Math*

## ■ Java naming convention

- Class name in **UpperCamelCase**
  - Eg: “class SumIntegers”, “class Vehicle”, “class GeometricShape”
- Variable names in **LowerCamelCase**
  - Eg: “int count”, “double boxHeight”, “char checkCode”
- Constant names in uppercase, words separated by underscore
  - Eg: “KMS\_PER\_MILES”, “PI”, “PASSING\_MARK”



- This week, the Java programs shown do not truly use object-oriented programming (OOP) features
- We will learn some OOP concepts next week

When you see this icon at the top right corner of the slide, it means that in the interest of time the slide might be skipped over in lecture and hence is intended for your own reading.

# Thank you!

