ĐẠI HỌC TÔN ĐỨC THẮNG
TON DUC THANG UNIVERSITY

Data Structures and Algorithms I

Introduction to Java

Acknowledgement

- The contents of these slides have origin from School of Computing, National University of Singapore.
- We greatly appreciate support from Mr. Aaron Tan Tuck Choy, and Dr. Low Kok Lim for kindly sharing these materials.

Policies for students

- These contents are only used for students PERSONALLY.
- Students are NOT allowed to modify or deliver these contents to anywhere or anyone for any purpose.

Recording of modifications

- Course website address is changed to http://sakai.it.tdt.edu.vn
- Slide “References for Java Style Guides” is eliminated.
- Slide “Our assumptions!” is eliminated.
- Slides “Practice Exercises” are eliminated.
- Course codes cs1010, cs1020, cs2010 are placed by 501042, 501043, 502043 respectively.

Objectives

Java

Basic Java features

C → Java

Translate C programs in 501042 into Java programs

References

Chapter 1

- Section 1.1 (excludes Arrays) to Section 1.5: pages 27 to 45
- Section 1.7 (excludes Console class): pages 73 to 77

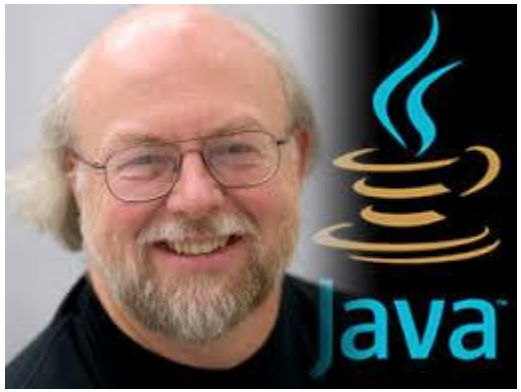
IT-TDT Sakai → 501043 website → Lessons

- http://sakai.it.tdt.edu.vn

Outline

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

1. Java: Brief History & Background



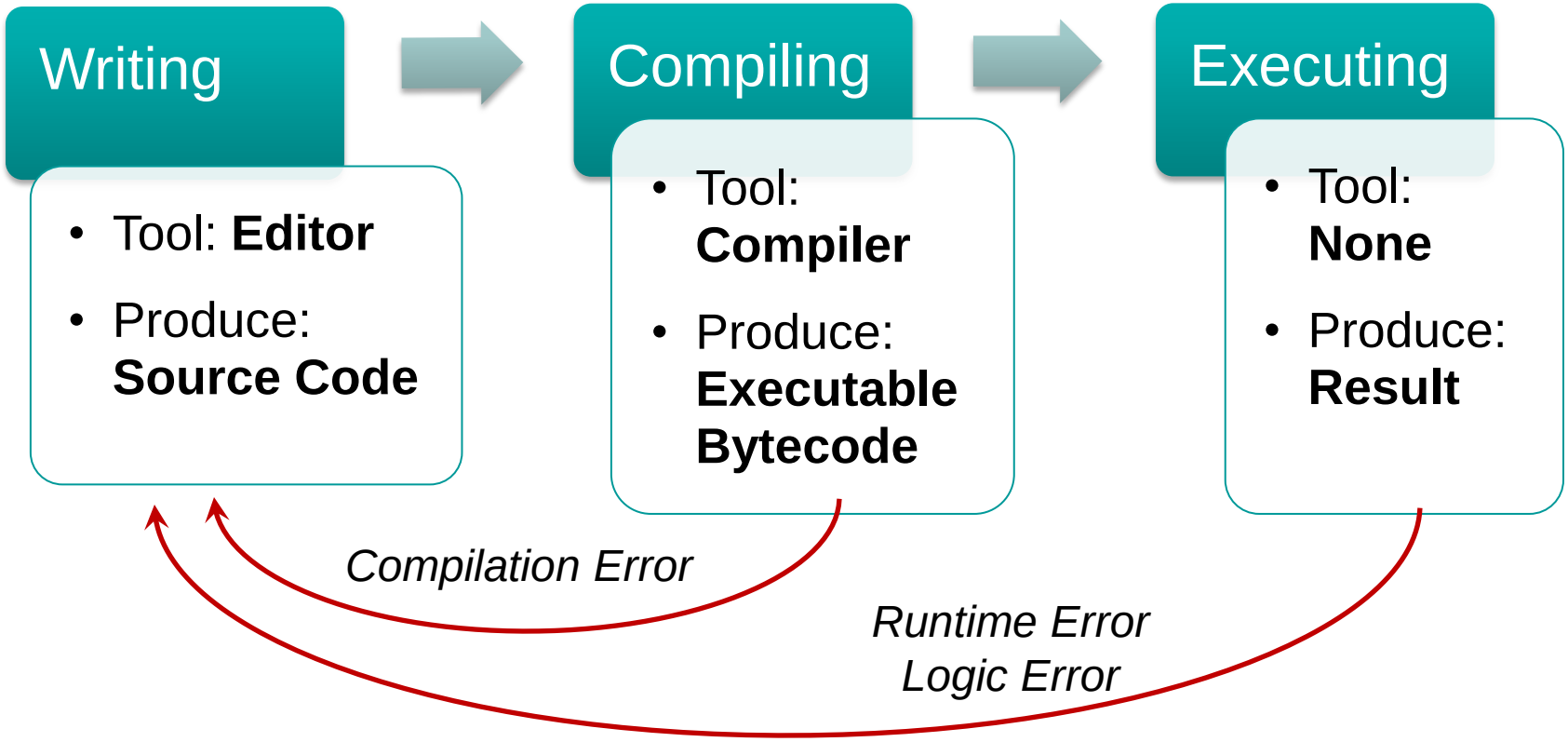
James Gosling
1995, Sun Microsystems

Use C/C++ as foundation
- "Cleaner" in syntax
- Less low-level machine interaction

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

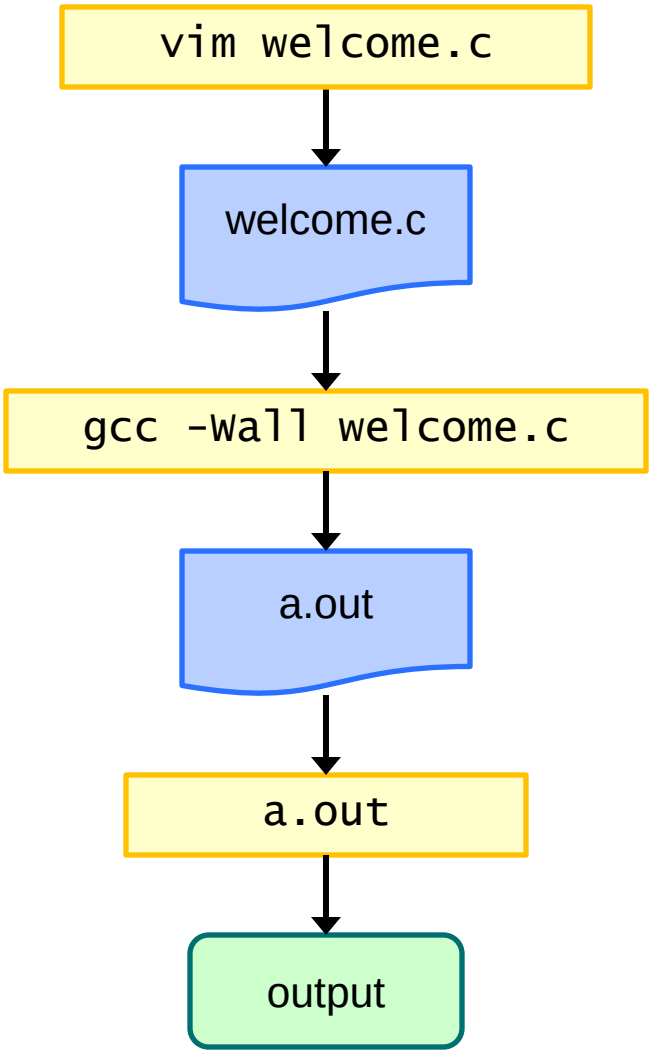
- Less efficient

Recap: Process



Recap: Run Cycle for C Programs

- 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

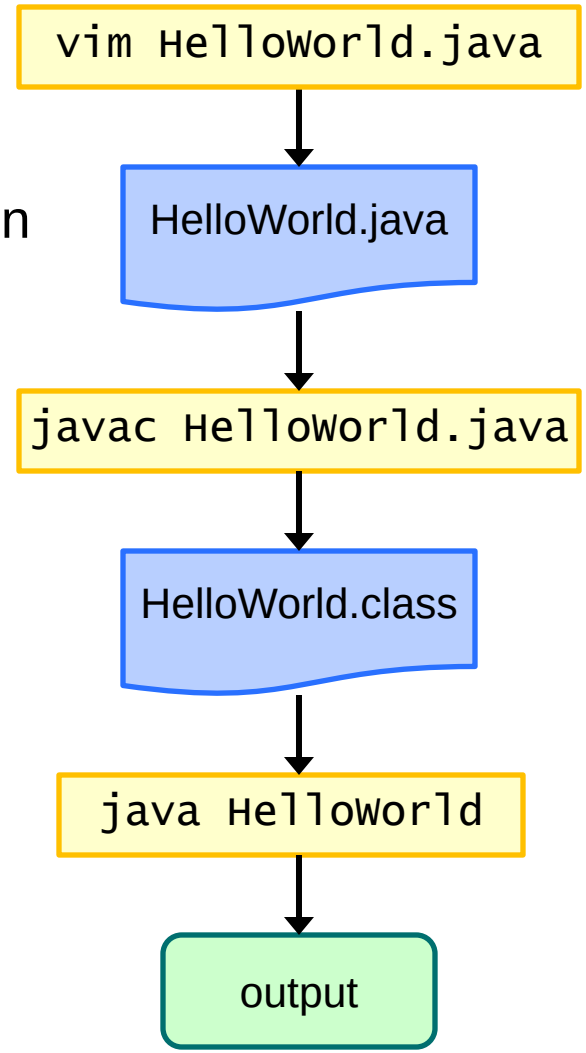


Java: Compile Once, Run Anywhere?

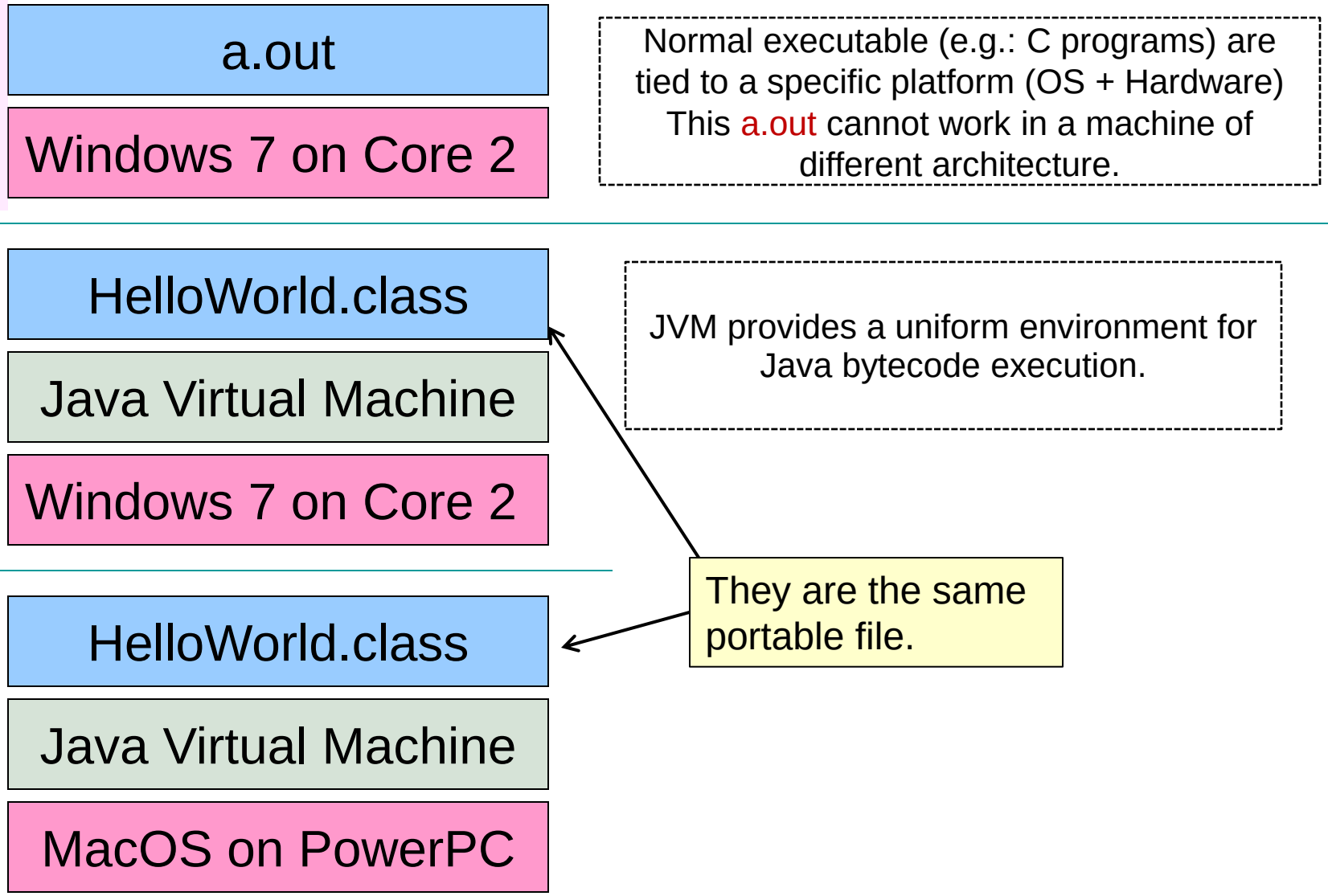
- Normal executable files are directly dependent on the OS/Hardware
  - Hence, an executable file is usually not executable on different platforms
  - E.g: The a.out file compiled on sunfire is not executable on your Windows computer
- Java overcomes this by running the executable on an uniform hardware 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

Run Cycle for Java Programs

- 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



Java Execution Illustration



3. Basic Java Program Structure

- 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 programs done in 501042 into Java
- We will gradually cover many other Java features over the next few weeks

Hello World!

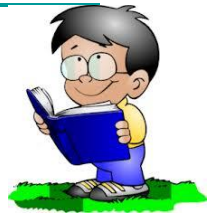

```c
#include <stdio.h>

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.



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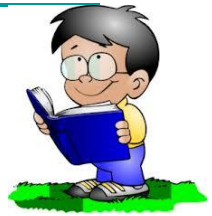
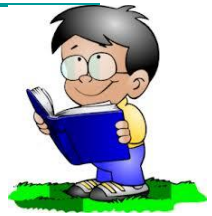
Key Observations (1/2)



- 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

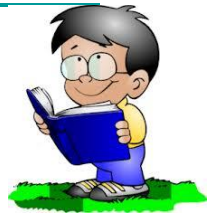
Key Observations (2/2)



- 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)

4.1 Arithmetic Expressions

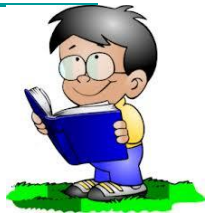
4.1 Identifier, Variable, Constant (1/2)



- **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:

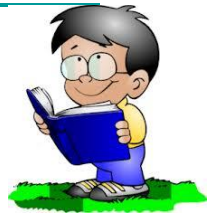
```
int countDays;
double priceOfItem;
```

4.1 Identifier, Variable, Constant (2/2)



- **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 501043 website → Resources → Online:
  - http://sakai.it.tdt.edu.vn
  - 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`**

4.1 Numeric Data Types

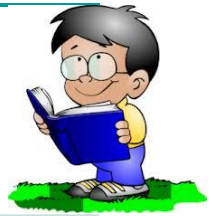


- Summary of numeric data types in Java:

	Type Name	Size (#bytes)	Range
Integer Data Types	`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 $2^{63}-1$
Floating-Point Data Types	`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

4.1 Numeric Operators



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 Shorthand Operators	Right-to-left

- 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

4.1 Numeric Data Type Conversion

- 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**

4.1 Data Type Conversion

- 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.

4.1 Problem: Fahrenheit to Celsius

- 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

4.1 Solution: Fahrenheit to Celsius

Temperature.java

```
public class Temperature {

  public static void main(String[] args) {

     double fahrenheit, celsius;

     fahrenheit = 123.5;
     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)

4.2 Control Statements

Program Execution Flow

4.2 Boolean Data Type [new in Java]

- 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

```
boolean variable;
```

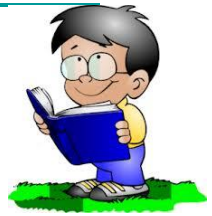
Example

```
boolean isEven;
int input;
// code to read input from user omitted
if (input % 2 == 0)
      isEven = true;
else
     isEven = false;
if (isEven)
      System.out.println("Input is even!");
```

Equivalent:

```
isEven = (input % 2 == 0);
```

4.2 Boolean Operators



	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)
```

4.2 Comparison with C

- 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.");
```

4.2 Selection Statements

```
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

4.2 Repetition Statements (1/2)

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

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

- Valid conditions:
  - **Must be a *boolean* expression**
- `while` : check condition before executing body
- `do-while`: execute body before condition checking

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

- `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, …`

4.2 Repetition Statements (2/2)

- 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++) {
    ...
}
```

4.3 Basic Input/Output

Interacting with the outside world

4.3 Reading input: The Scanner Class

PACKAGE

```
import java.util.Scanner;
```

SYNTAX

```
//Declaration of Scanner "variable"
Scanner scVar = new Scanner(System.in);

//Functionality provided
scVar.nextInt();
```

Read an integer value from source System.in

```
scVar.nextDouble();
```

Read a double value from source System.in

```
......
```

Other data types, to be covered later

4.3 Reading Input: Fahrenheit Ver 2

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

public class TemperatureInteractive {

  public static void main(String[] args) {

    double fahrenheit, celsius;
    Scanner sc = new Scanner(System.in);

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

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

  }

}
```

TemperatureInteractive.java

4.3 Reading Input: Key Points (1/3)

- 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

4.3 Reading Input: Key Points (2/3)

- 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

4.3 Reading Input: Key Points (3/3)

- 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 in your program.

4.3 Writing Output: The Standard Output

- **`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
```

4.3 Writing Output: printf()

- 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

4.3 Problem: Approximating PI

- One way to calculate the PI (π) constant:

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

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

4.3 Solution: Approximating PI

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

public class ApproximatePI {

  public static void main(String[] args) {

     int nTerms, sign = 1, denom = 1;
     double pi = 0.0;

     Scanner sc = new Scanner(System.in);

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

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

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

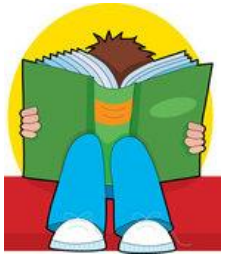
ApproximatePI.java

4.4 API

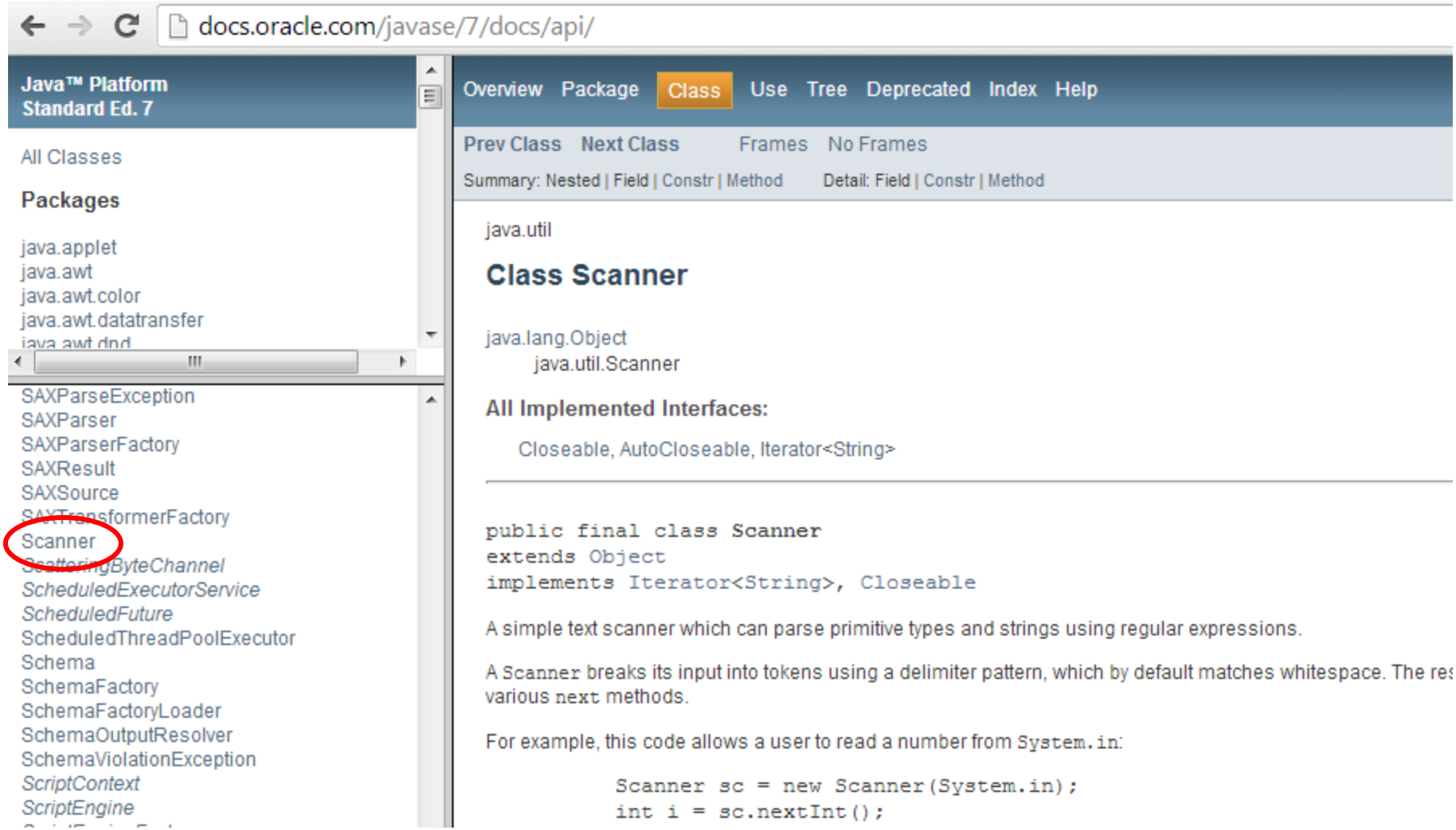
Application Programming Interface

4.4 API (1/2)

- 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/
  - You may also access the above link through 501043 website → Resources → Online (http://sakai.it.tdt.edu.vn)
  - 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



4.4 API (2/2)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All Classes
Packages
java.applet
java.awt
java.awt.color
java.awt.datatransfer
SAXParseException
SAXParser
SAXParserFactory
SAXResult
SAXSource
Scanner
ScheduledExecutorService
ScheduledFuture
ScheduledThreadPoolExecutor
Schema
SchemaFactory
SchemaFactoryLoader
SchemaOutputResolver
SchemaViolationException
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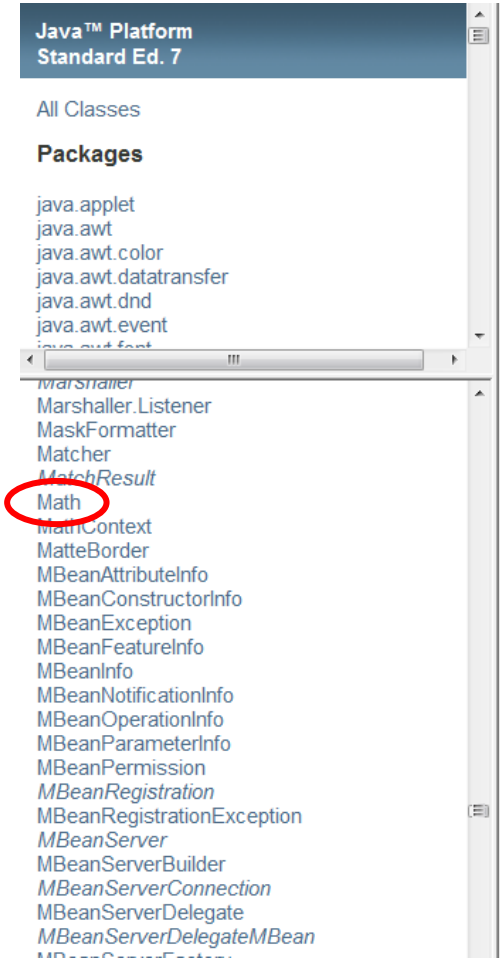
Prev Class Next Class Frames No Frames
Summary: Nested | Field | Constr | Method Detail: Field | Constr | Method
java.util
Class Scanner
java.lang.Object
java.util.Scanner
All Implemented Interfaces:
Closeable, AutoCloseable, Iterator<String>
public final class Scanner
extends Object
implements Iterator<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 res
various next methods.
For example, this code allows a user to read a number from System.in:
Scanner sc = new Scanner(System.in);
int i = sc.nextInt();

4.5 Math class, Class Attributes

Using the Math class

4.5 The Math class (1/2)

- From the API documentation



Modifier and Type	Field and Description
static double	**E** The double value that is closer than any other to *e*, the base of the natural logarithms.
static double	**PI** The double value that is closer than any other to *pi*, the ratio of the circumference of a cir

Method Summary

Methods

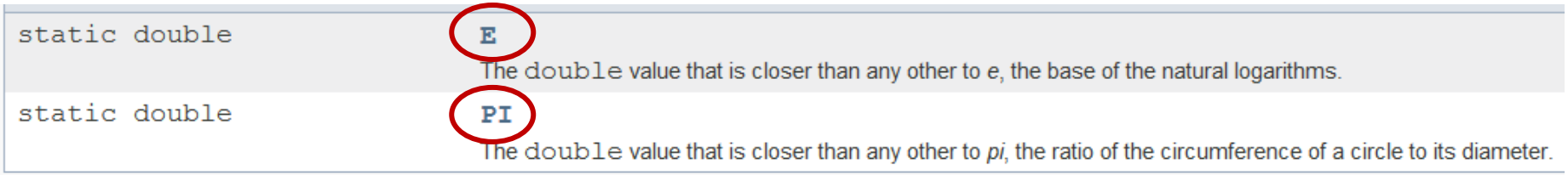
Modifier and Type	Method and Description
static double	**abs**(double a) Returns the absolute value of a double value.
static float	**abs**(float a) Returns the absolute value of a float value.
static int	**abs**(int a) Returns the absolute value of an int value.
static long	**abs**(long a) Returns the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

4.5 The Math class (2/2)

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

4.5 Class Attributes

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



`static double`	**`E`** The `double` value that is closer than any other to *e*, the base of the natural logarithms.
`static double`	**`PI`** The `double` value that is closer than any other to *pi*, 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:

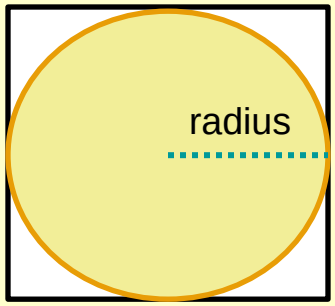
```
double area = Math.PI * Math.pow(radius,2);
```

  - Here, **`Math.PI`** is used as the constant π

4.5 The Math class: Demo

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);
  }
}
```



4.6 User-defined Functions

Reusable and independent code units

4.6 Function with a new name

- 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 {

  // Returns n!
  // Pre-cond: n >= 0
  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?

4.6 Method Parameter Passing

- 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

Summary

Java Elements

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*

Next Week: Real OOP

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

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