ĐẠI HỌC TÔN ĐỨC THẮNG
TON DUC THANG UNIVERSITY

# OBJECT-ORIENTED PROGRAMMING

## 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.

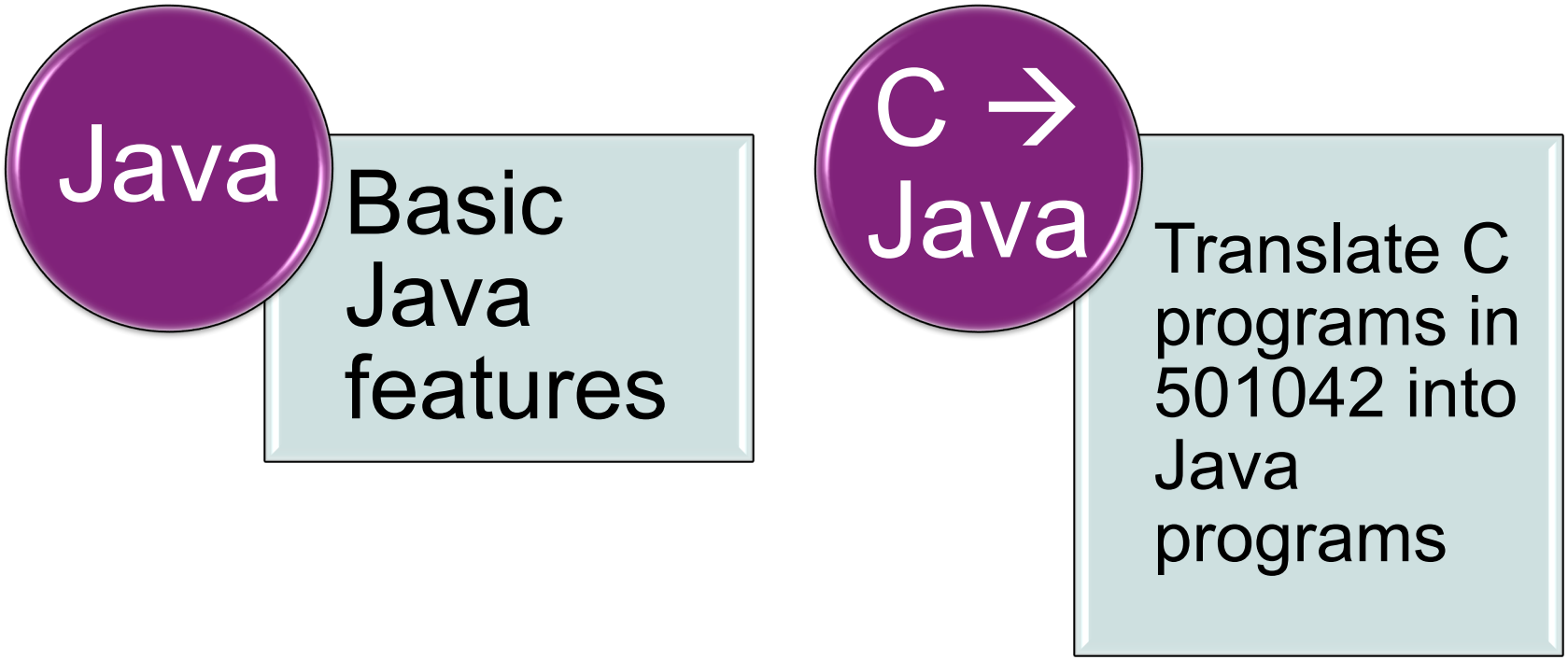
# Policies for students

- 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

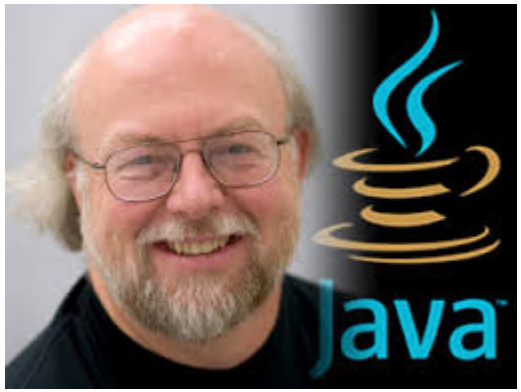

## IT-TDT Sakai → 501043 website → Lessons

- 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



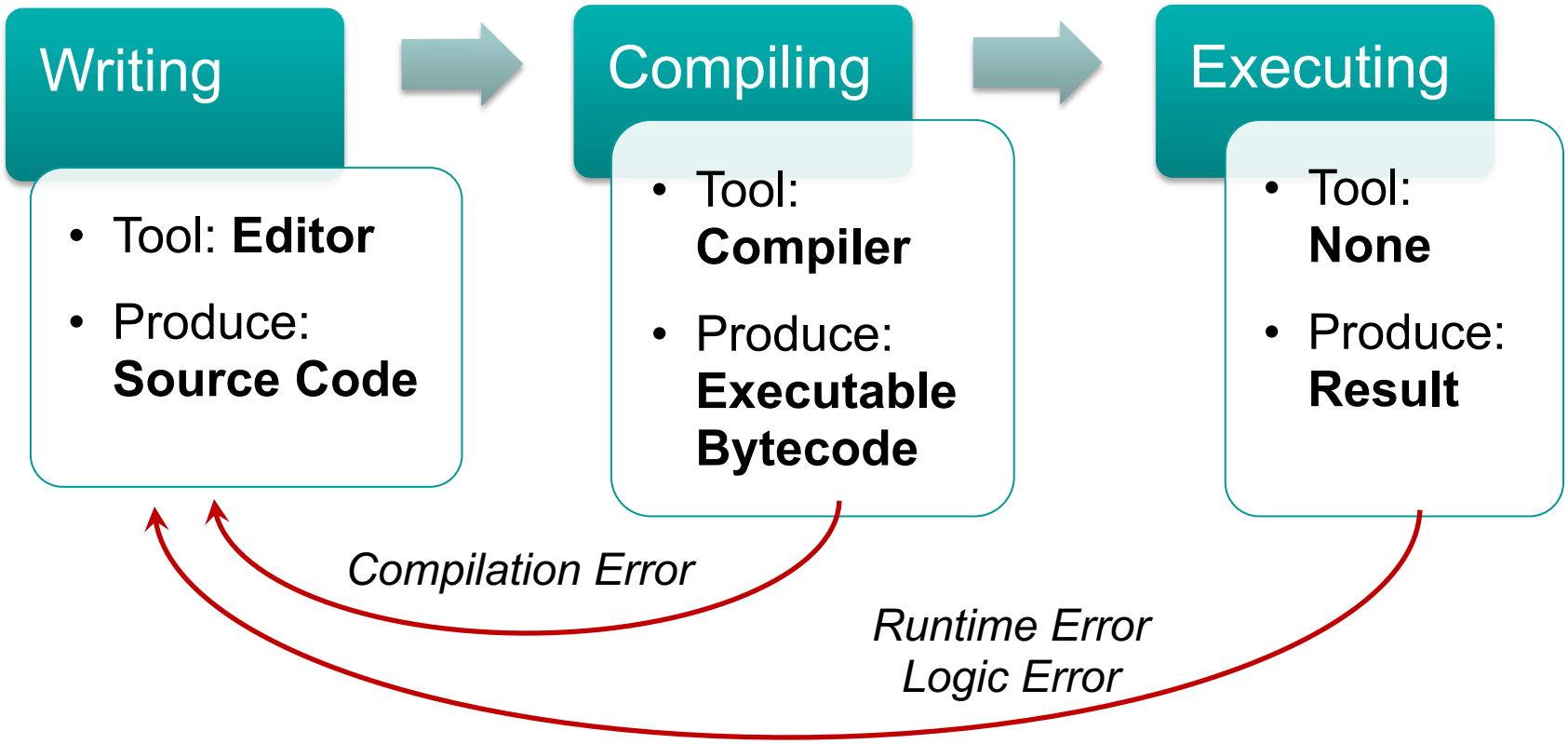

James Gosling
1995, Sun Microsystems

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

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

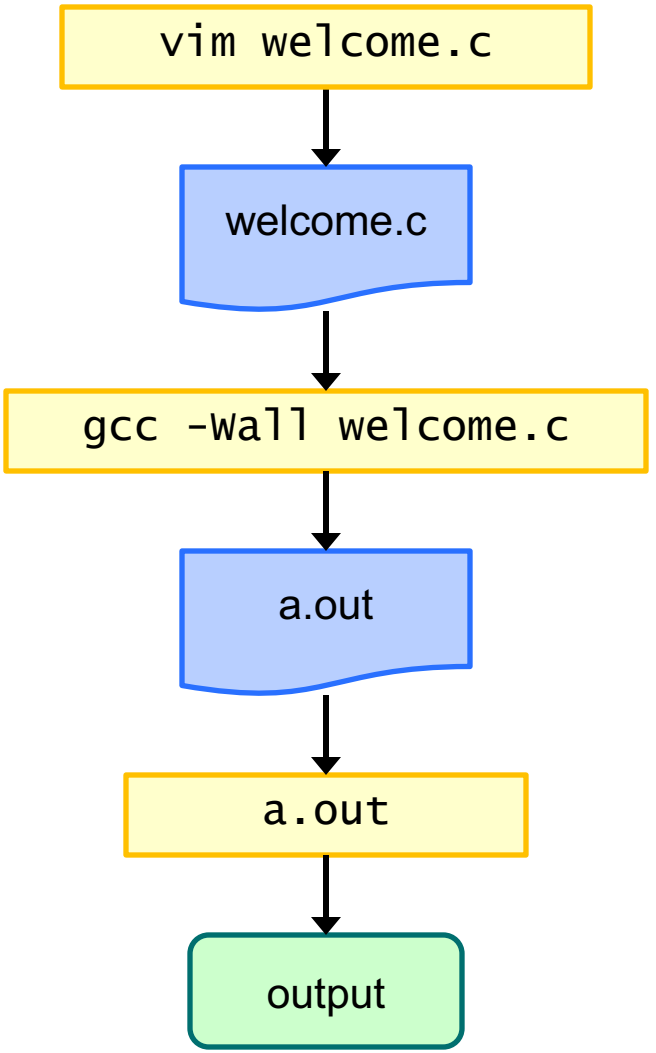
- Less efficient

# 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

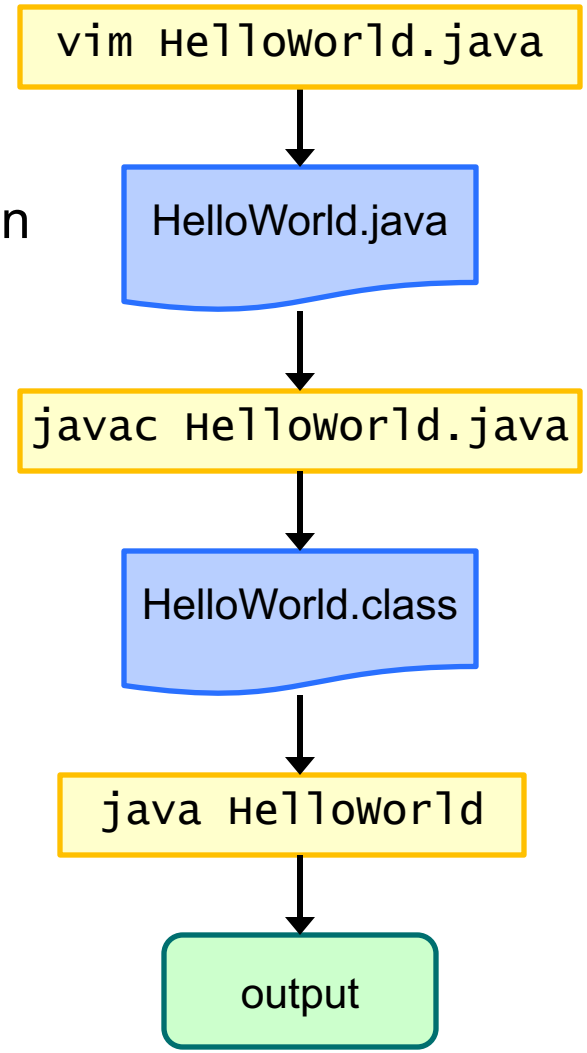


# Java: Compile Once, Run Anywhere?

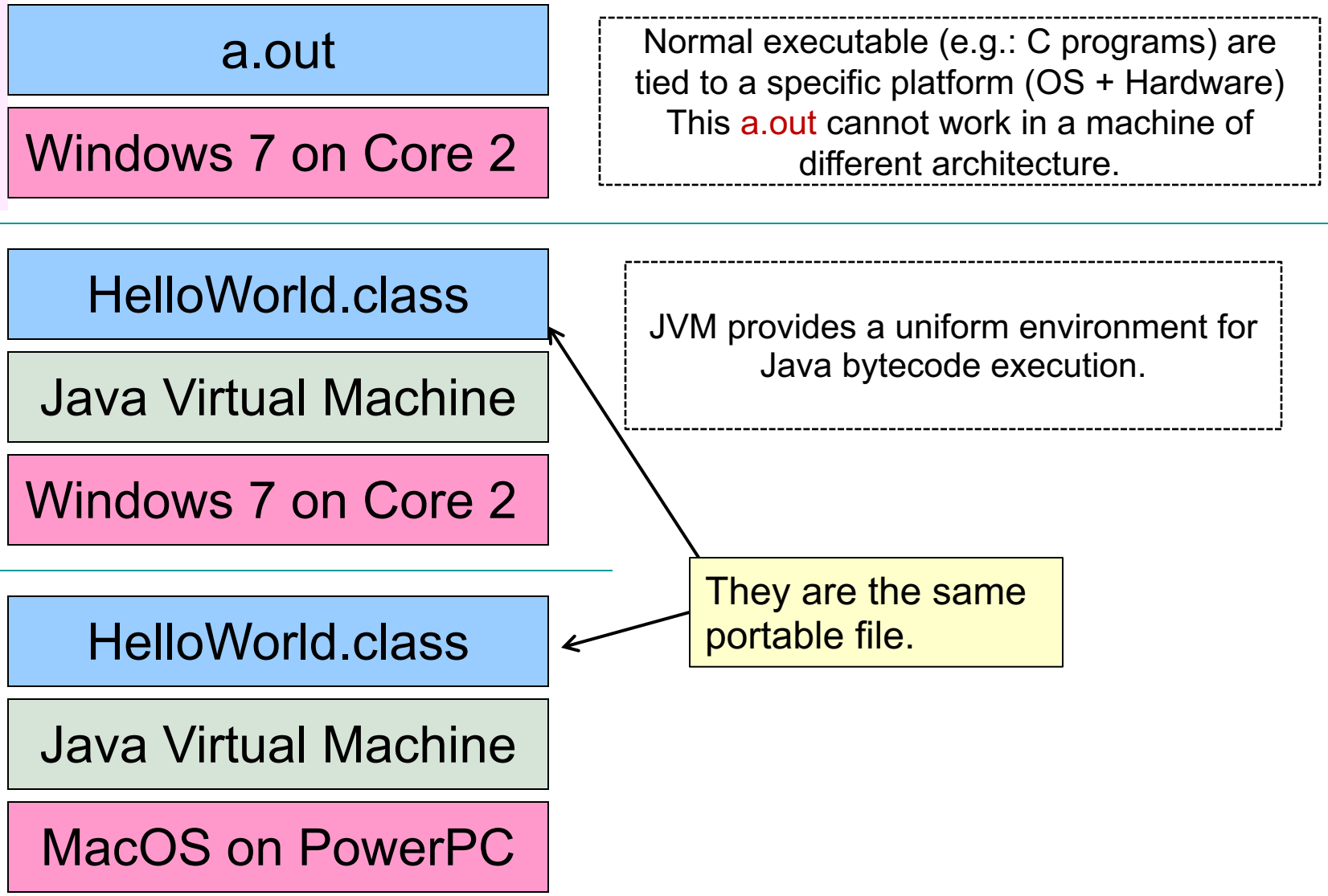
- Normal executable files are directly dependent on the OS/Hardware
  - Hence, an executable file is usually not executable on different platforms
  - E.g: The a.out file compiled on sunfire is not executable on your Windows computer
- Java overcomes this by running the executable on an uniform hardware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

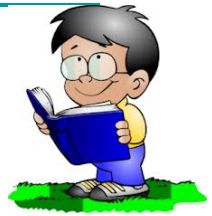

```c
#include <stdio.h>

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!");

  }

}
```

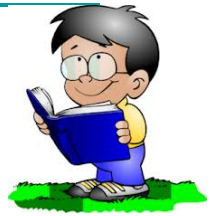
HelloWorld.java

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



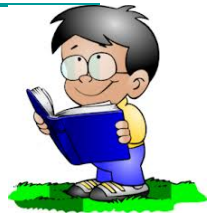
When you see this icon at the top right corner of the slide, it means that in the interest of time the slide might be skipped over in lecture and hence is intended for your own reading.

# 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

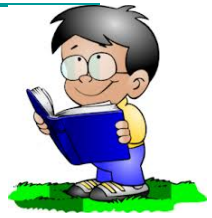
# Key Observations (2/2)



- 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

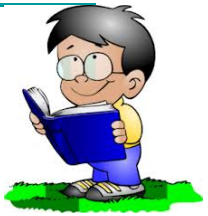
# 4.1 Identifier, Variable, Constant (1/2)



- **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:

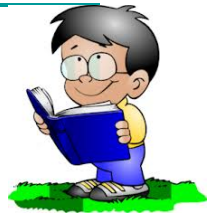
```
int countDays;
double priceOfItem;
```

# 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

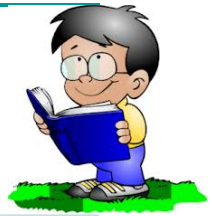


- Summary of numeric data types in Java:

| | 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<br>Positive: 1.4E-45 to 3.4028235E+38 |
| | `double` | 8 | **Negative: -1.7976931348623157E+308 to -4.9E-324**<br>**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 |
| `++, --`<br>`+, -` | Prefix incrementor/decrementor<br>Unary +, - | Right-to-left |
| `*, /, %` | Multiplication, Division,<br>Remainder of division | Left-to-right |
| `+, -` | Addition, Subtraction | Left-to-right |
| `=`<br>`+= -= *= /= %=` | Assignment Operator<br>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;
```

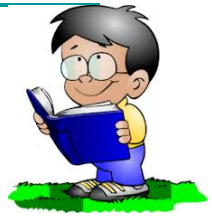
**Example**

```
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 ($\pi$) constant:

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

- 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

# 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

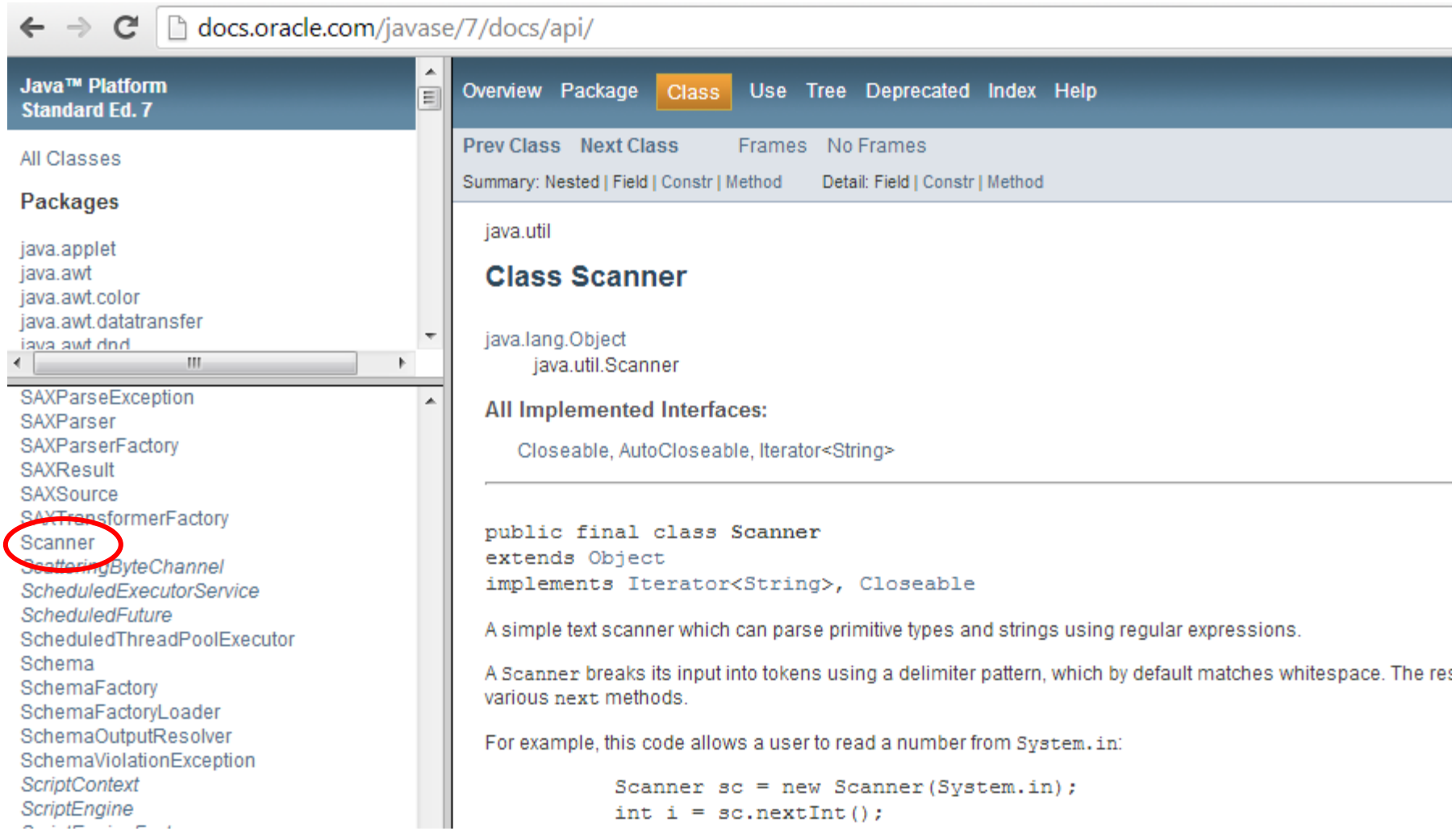
# 4.4 API

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)

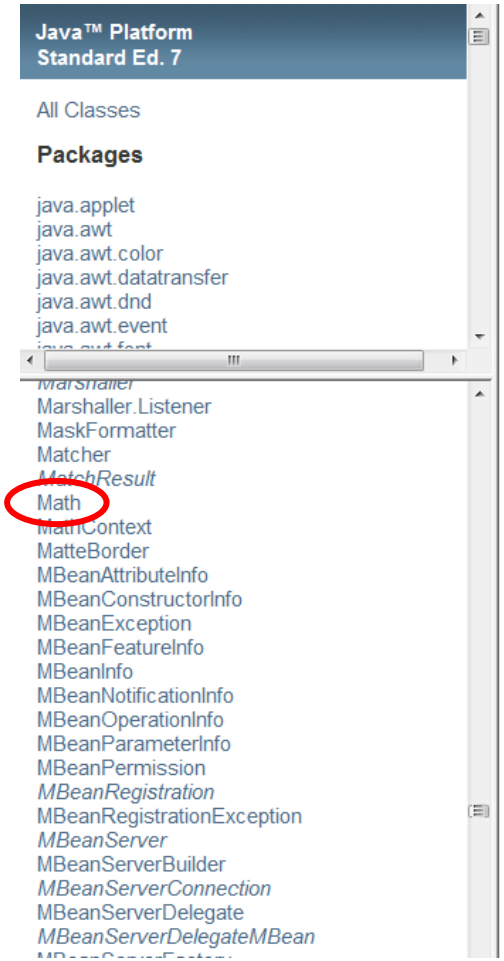

docs.oracle.com/javase/7/docs/api/
Java™ Platform
Standard Ed. 7
All Classes
Packages
java.applet
java.awt
java.awt.color
java.awt.datatransfer
SAXParseException
SAXParser
SAXParserFactory
SAXResult
SAXSource
Scanner
ScheduledExecutorService
ScheduledFuture
ScheduledThreadPoolExecutor
Schema
SchemaFactory
SchemaFactoryLoader
SchemaOutputResolver
SchemaViolationException
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 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**<br>The double value that is closer than any other to *e*, the base of the natural logarithms. |
| static double | **PI**<br>The double value that is closer than any other to *pi*, the ratio of the circumference of a cir |

## Method Summary

Methods

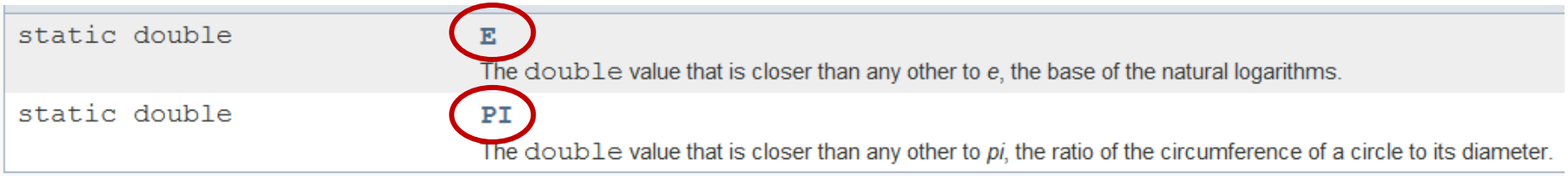
| Modifier and Type | Method and Description |
|---|---|
| static double | **abs**(double a)<br>Returns the absolute value of a double value. |
| static float | **abs**(float a)<br>Returns the absolute value of a float value. |
| static int | **abs**(int a)<br>Returns the absolute value of an int value. |
| static long | **abs**(long a)<br>Returns the absolute value of a long value. |
| static double | **acos**(double a)<br>Returns the arc cosine of a value; the returned angle is in the range 0.0 through *pi*. |
| static double | **asin**(double a)<br>Returns the arc sine of a value; the returned angle is in the range -*pi*/2 through *pi*/2. |
| static double | **atan**(double a)<br>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`**<br>The `double` value that is closer than any other to *e*, the base of the natural logarithms. |
| `static double` | **`PI`**<br>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:

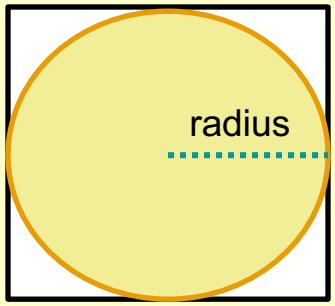
```
double area = Math.PI * Math.pow(radius,2);
```

  - Here, **`Math.PI`** is used as the constant $\pi$

# 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*

End of file