



OBJECT-ORIENTED PROGRAMMING

Introduction to Java

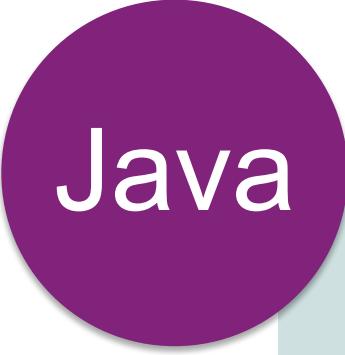
Acknowledgement

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Policies for students

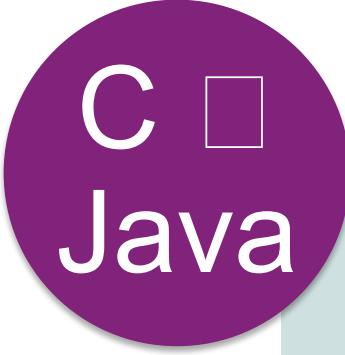
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Objectives



Java

Basic
Java
features



C
Java

Translate C
programs in
501042 into
Java
programs

References



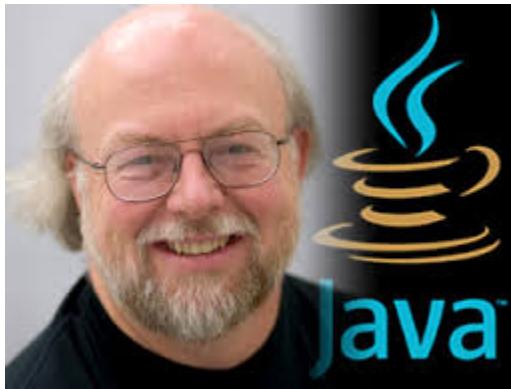
Chapter 1

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

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

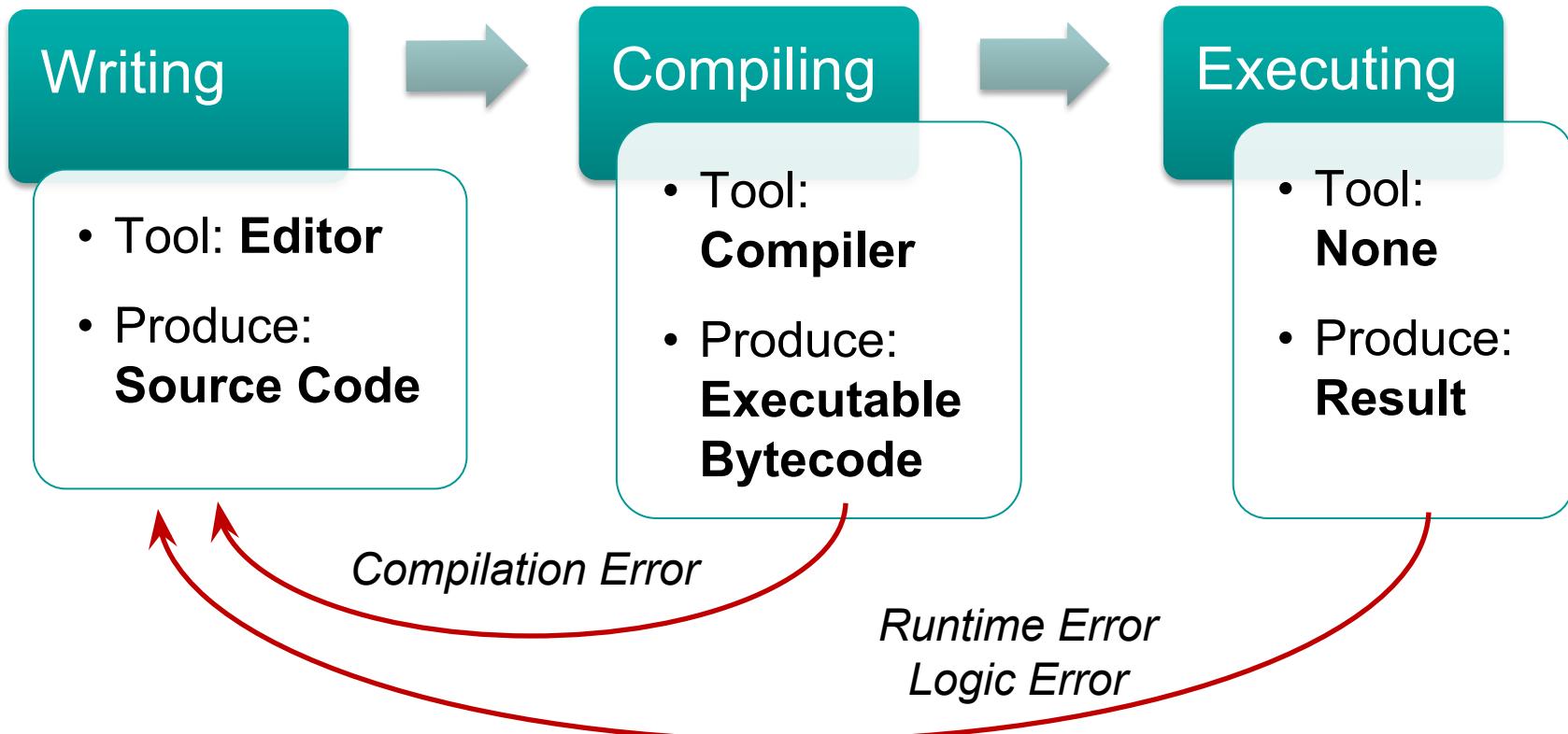
- “Cleaner” in syntax
- Less low-level machine interaction



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

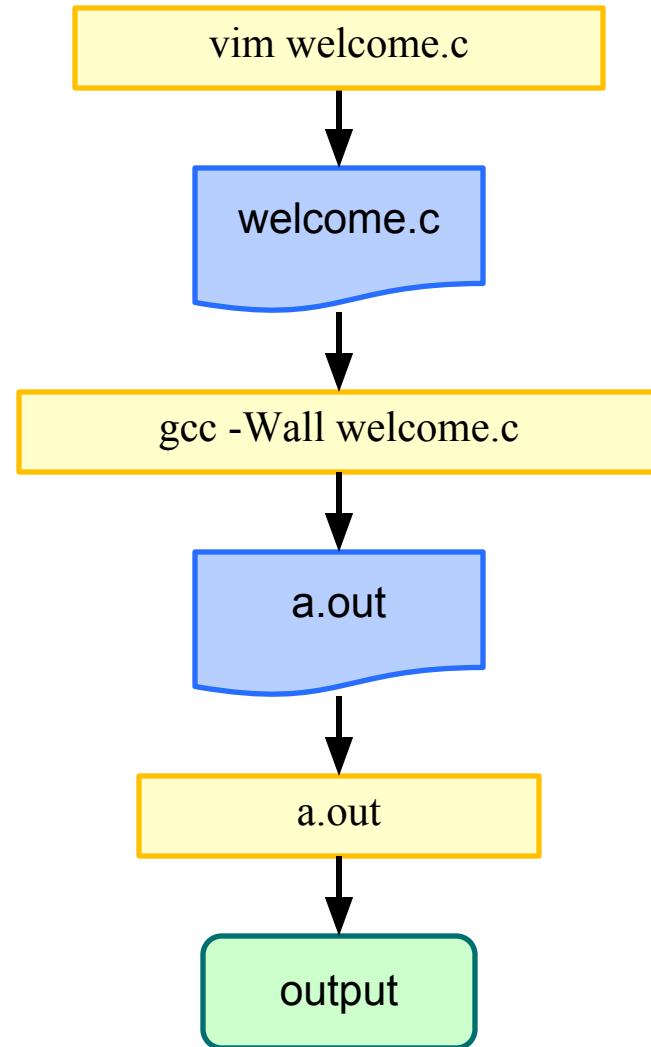
- Less efficient

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

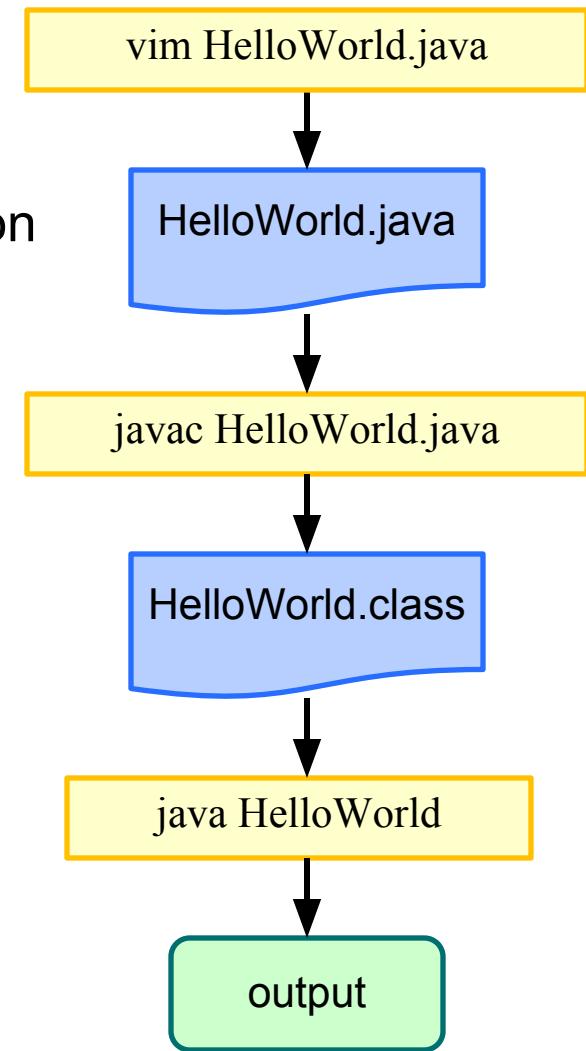


Java: Compile Once, Run Anywhere?

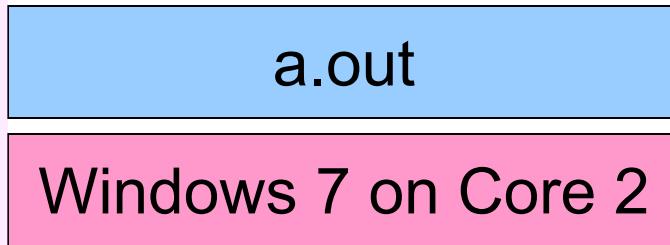
- Normal executable files are directly dependent on the OS/Hardware
 - Hence, an executable file is usually not executable on different platforms
 - E.g: The **a.out** file compiled on sunfire is not executable on your Windows computer
- Java overcomes this by running the executable on an **uniform hardware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

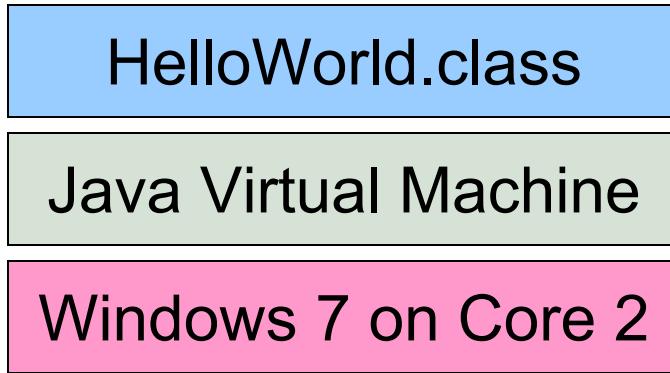
- Writing/Editing Program
 - Use a text editor, e.g: vim
 - Source code must have **.java** extension
- Compiling Program
 - Use a Java compiler, e.g.: **javac**
 - Compiled binary has **.class** extension
 - The binary is also known as **Java Executable Bytecode**
- Executing Binary
 - Run on a **Java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



Java Execution Illustration



Normal executable (e.g.: C programs) are tied to a specific platform (OS + Hardware)
This **a.out** cannot work in a machine of different architecture.



JVM provides a uniform environment for Java bytecode execution.



They are the same portable file.

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

3. Basic Structure

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.

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 XXXXX;`” 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:
 - 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
byte	1	-2 ⁷ to 2 ⁷ -1
short	2	-2 ¹⁵ to 2 ¹⁵ -1
int	4	-2³¹ to 2³¹-1
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

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`?

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?

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

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

```
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);  
    }  
}
```

Temperature.java

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**

SYNTA

X **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);
```

```
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, ...**

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 initialization 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:

```
ABCDE  
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:

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

SYNTAX	<code>%[-] [W] . [P] type</code>
-	: For left alignment
W	: For width
P	: For precision

4.3 Problem: Approximating PI

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

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

- Write [ApproximatePI.java](#) to:
 - Ask the user for the number of terms to use for approximation
 - Calculate π with the given number of terms
 - 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);
    }
}
```

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

ApproximatePI.java

Exercise

Write a program to check whether a number entered by the user from the keyboard is prime or not and print out the result.

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/>
 - 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)

The screenshot shows a browser window displaying the Java API documentation for the `Scanner` class. The URL is docs.oracle.com/javase/7/docs/api/. The page title is "Java™ Platform Standard Ed. 7". The navigation bar includes links for Overview, Package, Class (which is highlighted in orange), Use, Tree, Deprecated, Index, and Help. Below the navigation bar are links for Prev Class, Next Class, Frames, and No Frames. The summary section includes links for Nested, Field, Constr, Method and Detail: Field, Constr, Method.

The main content area shows the `java.util.Scanner` class, which extends `Object` and implements `Iterator<String>` and `Closeable`. A circled red circle highlights the word `Scanner` in the list of implemented interfaces.

```
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 page continues with examples and code snippets.

4.5 Math class, Class Attributes

Using the Math class

4.5 The Math class (1/2)

From the API documentation

The screenshot shows the Java™ Platform Standard Ed. 7 API documentation. On the left, there's a sidebar with links for 'All Classes' and 'Packages'. Under 'Packages', the 'java.lang' package is expanded, showing classes like `Math`, which is circled in red. The main content area has two tables. The top table is titled 'Field Summary' and lists the static fields `E` and `PI`. The bottom table is titled 'Method Summary' and lists various static methods of the `Math` class, each with its description.

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 circle to its diameter.

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

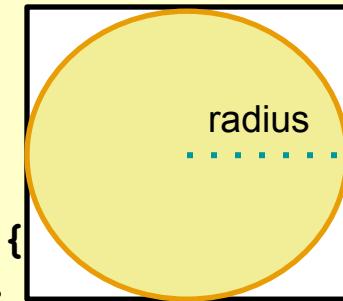
```
        System.out.print("Enter area of a square: ");  
        double areaSquare = sc.nextDouble();
```

```
        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

```
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);  
    }  
}
```

Factorial.java

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

```
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));  
}  
}
```

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

Exercise (score management)

Write the program to enter the score of 3 subjects: Math, Literature, and English. To calculate the average score, the Math score will multiply by 2, and sum it with the Literature score and English score, all divided by 4. Print out the ranks A, B, or C. Given that, if the average score is greater than or equal to 8.0, the rank will be A. If the average score is smaller than 8.0 and greater than or equal to 5.0, the rank will be B. And in other cases, the rank will be C. Students must define at least 02 functions to solve this program.

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