Java

Java

- Java is object oriented.
- Java works on most platforms. While C/C++ programs are platform specific.
- Java is network enabled. It is trivially simple to write code in Java that works across networks.

What is JVM?

- It is a hypothetical processor which executes java programs.
- The java compilers produces binary byte code designed to execute on JVM rather than on a PC or Sun Workstation.
- It is abbreviated as Java Virtual Machine.

Declaring Variables

- Java requires that you ***declare*** every variable before you can use it.

- You can declare the variables in several ways. Often, you declare several at the same time.

```
int y, m, x //all at once
```

or one at a time.

```
int y; //one at a time
int m;
int x;
```

Declaring Variables (cont…)

- You can also declare the variables as you use them.

```
int x = 4;
int m = 8;
int b = -2;
```

- However, you MUST declare variables by the time you first refer to them.

Constants

- Constants can be defined by using the final modifier.
- It is a good practice to CAPITALIZE symbols referring to constants.
- Examples

```
final float PI = 3.1416;
final int NUMBER_OF_DAYS_IN_MONTH = 30;
```

Data Types

Type	**Contents**
boolean	true or false
byte	Signed 8-bit value
short	16-bit integer
int	32-bit integer
long	64-bit integer
float	32-bit floating point
double	64-bit floating point
char	16-bit unicode character

Data Type Conversions

- Any "wider" data type can have a lower data type assigned directly to it and the promotion to the new type will occur automatically.

- For example, If *y* is of type **float** and *j* is of type **int** then you can write:
  - `float y; //y is of type float`
  - `int j; //j is of type int`
  - `y = j; //convert int to float`

  to promote an integer to a float.

Data Type Conversions (cont…)

- You can reduce a wider type to a narrower type using by *casting i*t. You do this by putting the data type name in parentheses and putting this name in front of the value you wish to convert:

- For example,

```
j = (int)y; //convert float to integer
```

Boolean Data Type

- Boolean variables can only take on the values represented by the reserved words **true** and **false**.

Unlike C, you cannot assign numeric values to a boolean variable and you cannot convert between **boolean** and any other type.

Numeric Data Types

- Any number you type into your program is automatically of type **int** if it has no fractional part or of type **double** if it does.

- For example in a program if a number, say 5.5 is used then it will be of double data type by default.

Numeric Data Types (cont…)

- If you want to indicate that it is a different type, you can use various suffix and prefix characters to indicate what you had in mind.

- For example,

```
float loan = 1.23f; //float
long pig = 45L; //long
long color = 0x12345; //hexadecimal
```

Simple Java Program

```
import java.io.*
public class Add2 {

 public static void main(String argv[ ]) {
     double a, b, c;
      a = 1.75;
      b = 3.46;
      c = a + b;

      // print out sum
      System.out.println("sum = " + c);
   }
 }
```

Output : sum = 5.21

import statement

- You must use the **import** statement to define libraries or *packages* of Java code that you want to use in your program
- This is similar to the C and C++ **#include** directive.

“main” Method

- The program starts from a function called **main** and it must have *exactly* the form shown here:

```
public static void main(String argv[])
```

or

```
public static void main(String[] argv)
```

Comments

- Single line comments start with "//" (double forward slash)

- Multiple lines can be commented by enclosing the required code block between /* and */

Class Definition

- Every program module must contain one or more classes.
- The class and each function within the class is surrounded by *braces* ({ }).
- Like most other languages the equals sign is used to represent assignment of data.

String concatenation

- You can use the “+” sign to combine two strings. The string “sum =” is concatenated with the string representation of the double precision variable **c**.

Arithmetic Operators

+	Addition
-	Subtraction, Unary Minus
*	Multiplication
/	Division
%	Modulus

Assignment Operators

=	Assignment
+= -= *= /= **etc**	Compound assignment

Increment & Decrement Operators

- Java allows you to express incrementing and decrementing of integer variables using the “++” and “--” operators.

- For example

```
i = 5; j = 10;
x= i++  //x = 5, then i = 6
y = --j; //y = 9 , j = 9;
```

Control structures

Making decisions in Java

- The familiar if-then-else of Visual Basic has its analog in Java. Note that in Java, however, we do not use the “then” keyword. For Example,

```
if ( y > 0 )
 z = x / y;
```

- Parentheses around the condition are REQUIRED in Java.

Making decisions in java (cont…)

- If you want to have several statements as part of the condition, you must enclose them in braces:

```
if (y > 0) {
 z = x / y;
 System.out.println("z = " + z);
}
```

Comparison Operators

Java	**Meaning**
>	Greater than
<	Less than
= =	Is equal to
!=	Is not equal to
>=	Greater than or equal to
<=	Less than or equal to
!	Not
Note :- All of these operators return boolean results	

Logical operators

Operator	Meaning
&	Logical AND
|	Logical OR
&&	Shortcut Logical AND
||	Shortcut Logical OR

switch statement

```
switch(expression) {
 case constant : statements
 case constant : statements
 ----
 ----
 default : statements
}
```

switch statement - example

```
switch(number) {
 case 1: System.out.println(“One”);
         break;
 case 2: System.out.println(“Two”);
         break;
 case 3: System.out.println(“Three”);
         break;
 default : System.out.println(“Invalid”);
}
```

Loops

```
while(boolean-expression)
        statement
```

```
do
    statement
        while(boolean-expression);
```

```
for(initialization; boolean-expression; step)
        statement
```

break and continue

- You can also control the flow of the loop inside the body of any of the iteration statements by using **break** and **continue**
- **break** quits the loop without executing the rest of the statements in the loop
- **continue** stops the execution of the current iteration and goes back to the beginning of the loop to begin the next iteration
- For nested loops, labels can be used along with these statements to specify the loop

Classes and Objects

Class

- It is a basic unit in java programming language.
- It provides a structure for objects.
- Contract – A combination of methods, data and semantics.

Java Class Structure

```
package <package_name>;

import <other_packages>;

public class ClassName {
    <variables(also known as fields)>;

    <constructor(s)>;

    <other methods>;
}
```

Simple class

```
class BankAccount {
  private double balance = 0.0;
}
```

Class Members

1. Fields
2. Methods
3. Classes – Nested classes
4. Interfaces – Nested interfaces

Fields

- Class variables are called fields.
- Fields are data variables associated with a class and its objects.
- Instance variables – associated with objects
- Static variables – associated with class

Field Initialization

- When a field is declared it can be initialized by assigning it a valued of the corresponding type
  - `double zero = 0.0;` // constant
  - `double sum = 4.5 + 3.7;` // constant expression
  - `double zeroCopy = zero;` // field
  - `double rootTwo = Math.sqrt(2);` // method invocation
  - `double someVal = sum + 2 * Math.sqrt(rootTwo)`

Field Initialization *contd..*

- If a field is not initialized a default initial value is assigned to it depending on its type.

Type	**Default value**
boolean	false
char	‘\u0000’
int types	0
float	0.0f
double	0.0
Object ref	null

Final fields

- A final variable is one whose value cannot be changed after it has been initialized.
- Ex:

```
final double PI = 3.141592;
```

Methods

- Methods also are members of a class
- Method should have a type
- Type of a method is the type of data it returns
- If the method does not return a value its type is void
- ‘this’ can be used to refer instance variable explicitly

Method Overloading

- **Rules for method overloading：**

1. Overloaded methods *must* change the argument list.
2. Overloaded methods can change the return type.
3. Overloaded methods can change the access modifier.

Method Overloading

```
public static void main(String[] args) {
   Sales s = new Sales();

   System.out.println(s.computeSales(100));
   System.out.println(s.computeSales(100,2));
   System.out.println(s.computeSales(100,2,30));
}

class Sales {
   double computeSales(double price) {
         double sales;
         sales = price;
         return sales;
   }
   double computeSales(double price, int qty) {
         double sales;
         sales = price * qty;
         return sales;
   }
   double computeSales(double price, int qty, double discount) {
         double sales;
         sales = (price * qty) - discount;
         return sales;
   }
}
```

```
100.0
200.0
170.0
```

Static members

- Variables shared by all objects of a class are called static fields or class variables.

```
static int nextID;
```

- But, when accessed externally it must be accessed via class name.

  Ex: System.out

- Methods also can be static

Access control

- It provides a way to who has access to what members of a class.
  - **`private`** – accessible only in the class itself.
  - **`package`** – accessible in
    - classes in the same package
    - class itself
  - **`protected`** – accessible in
    - subclasses of any package
    - classes in same package,
    - the class itself.
  - **`public`** – accessible
    - anywhere the class is accessible.

Creating Objects

- Object of a class is created using the keyword – new
- Ex:-

```
BankAccount anAccount = new BankAccount()
anAccount.balance = 1000.00;
```

- You never delete objects. JVM manages memory for you using *garbage collection*.

Constructors

- Constructors are blocks of statements that can be used to initialize an object.
- Constructors have the same name as the class they initialize.
- Constructors take zero or more arguments.

Constructors (contd)

EX:

```
class BankAccount {
   double balance = 0.0
   BankAccount(double initialBalance) {
      balance = initialBalance
   }
}
```

Using constructor to create objects:

```
BankAccount anAccount = new BankAccount(1000.00);
```

Constructors (contd)

- All Java classes have constructors that are used to initialize a new object of that type
- A constructor has the **SAME NAME** as the class
- A constructor **DOESNOT** have return type.
- For example, a no argument constructor for `Stack` class can be

```
public Stack() {
    items = new Vector(10);
}
```

Constructors -Overloading

- Java supports name overloading for constructors so that a class can have any number of constructors, all of which have the same name

- For example, constructors for the stack classes can be
  - `public Stack()` // no argument ctor
  - `public Stack(int initialSize)` // 1 argument ctor

Default Constructor

- When writing your own class, you **DON'T HAVE** to provide constructors for it
- The default no argument constructor is automatically provided by the runtime system for any class that contains no constructors
- If a constructor with arguments is provided, default constructor is not automatically created by runtime system

Create Object

- A class provides the blueprint for objects
- Variable of class type is object reference
- Unless assigned with object reference, variable value is null

```
Point p1 = new Point(23, 94);
Rectangle r1 = new Rectangle(origin_one, 100, 200);
Point p2;    // value of p2 is  null
P1 = new Point(23,34);  // now p1 refers a new object
```

- **Referencing an Object's Variables (instance variables)**

  objectReference.variableName
- **Calling an Object's Methods (instance methods)**

  objectReference.methodName(argumentList);

Life Cycle Of an Object

Cleaning Up Unused Objects

- The Java runtime environment deletes objects when it determines that they are no longer used. This process is called *garbage collection*.
- An object is eligible for garbage collection when there are no more references to that object.
- We can explicitly drop an object reference by setting the variable to the special value *null*

Garbage Collector

- JRE has a garbage collector that periodically frees the memory used by objects that are no longer referenced.

Encapsulation

- Encapsulation is one of the four fundamental object-oriented programming concepts.
- The term *encapsulation* means to enclose in a capsule, or to wrap something around an object to cover it.
- Encapsulation covers, or wraps, the internal workings of a Java object.
  - Data variables, or fields, are hidden from the user of the object.
  - Methods, the functions in Java, provide an explicit service to the user of the object but hide the implementation.
  - As long as the services do not change, the implementation can be modified without impacting the user.

Public and Private Access Modifiers

- The `public` keyword, applied to fields and methods, allows any class in any package to access the field or method.
- The `private` keyword, applied to fields and methods, allows access only to other methods within the class itself.

- One way to hide implementation details is to declare all of the fields `private and methods as public`

String objects

String

- The String class represents character strings
- All string literals in Java programs, such as "abc", are implemented as instances of this class.
- Strings are constant; their values cannot be changed after they are created
- The class String includes methods for examining individual characters of the sequence, for comparing strings, for searching strings, for extracting substrings, and for creating a copy of a string with all characters translated to uppercase or to lowercase
- The Java language provides special support for the string concatenation operator (+), and for conversion of other objects to strings.

String (contd)

- Ways of creating String objects :

```
String s = “Hello”
String s = new String(“hello”);

char[ ]  ch = { ‘a’,’b’,’c’};
 String s = new String(ch);
```

String methods

Some of the methods

```
char charAt(int index)
String concat(String)
boolean equals(Object)
boolean equalsIgnoreCase(String)
int indexOf(String str)
int length()
String replace(char old, char new)
String substring(int begin, int end)   // begin to end – 1
String toLowerCase()
String toUpperCase()
String trim()
static String valueOf(alltypes)
```

StringBuffer & StringBuilder

Both classes represent mutable string objects

Both have same methods

StringBuffer is threadsafe, StringBuilder is not

Constructors

```
StringBuilder( )    // initial capacity 16
StringBuilder(int capacity)
StringBuilder(String st)      //create with capacity 16 + length of st
```

StringBuffer & StringBuilder

Some methods

StringBuilder append(alltypes)
int capacity( )
char charAt(int index)
int capacity()
StringBuilder delete(int start, int end) //start to end – 1
StringBuilder deleteCharAt(int index)
int indexOf(String)
StringBuilder insert(int offset, alltypes)
int length( )
StringBuilder replace(int start, int end, String new)
StringBuffer reverse( )

Arrays

- Arrays provide ordered collections of elements.
- Components of array can be primitive types or references to objects, including references to other arrays.
- Arrays themselves are objects and extend the class Object
- Examples:

```
int[] x = new int[3];
int y[] = new int[3];
```

Arrays (cont…)

- An `ArrayIndexOutOfBoundsException` is thrown if the index is out of bounds.
- The index expression must be of type int
- Implicit length variable used to know the size of the array
- An array with length zero is said to be an empty array.

Arrays - example

```
public class ArrayTest {
    public static void main(String[] args) {
      int a1[] = {10,34,56,23,67,87};
      int a2[];  // value is null
      int a3[] = new int[5];
      a2 = a1;  // a1 and a2 hold same array
/* use length to know the size of the array */
      for(int i=0;i<a1.length;i++)
            System.out.println(a1[i]);

}
```

Array of objects

- Array of objects is array of references to the objects as shown in this example

```
public class ArrayOfStringsDemo {
   public static void main(String[] args) {
     Test b[] = new Test[5];
     Test a[] = { new Test("Ramana"), new Test("Surender"),
                  new Test("Hiresh"), new Test("Haritha") };
       for (int i = 0; i < a.length; i++)  a[i].show();
   }
}
public class Test {
   private String name;
    public Test(String s) {
        name = s;
    }
    public void show() {
       System.out.println(name);
    }
}
```

Arrays and `for-each` Loop

```
1   public class ArrayOperations {
2       public static void main(String args[]){
3
4           String[] names = new String[3];
5
6           names[0] = "Blue Shirt";
7           names[1] = "Red Shirt";
8           names[2] = "Black Shirt";
9
10          int[] numbers = {100, 200, 300};
11
12          for (String name:names){
13              System.out.println("Name: " + name);
14          }
15
16          for (int number:numbers){
17              System.out.println("Number: " + number);
18          }
19      }
20  }
```

Arrays are objects.
Array objects have a final field length.

Multi dimensional arrays

- Multidimensional arrays are arrays of refences to arrays

```
String[][] cartoons = {
 { "Flintstones", "Fred", "Wilma", "Pebbles", "Dino" },
 { "Rubbles", "Barney", "Betty", "Bam Bam" },
 { "Jetsons", "George", "Jane", "Elroy", "Judy", "Rosie",
   "Astro" },
 { "Scooby Doo Gang", "Scooby Doo", "Shaggy", "Velma", "Fred",
   "Daphne" }
};

int x[][]  = new int[5][10];


int y[][] = new int[3][];
y[0] = new int[5];
y[1] = new int[10];
y[2] = new int[2];
```

Annotations

Annotations

- Annotations provide data about a program
- An **annotation** is an attribute of a program element.
- As of release 5.0, the platform has a general purpose annotation (metadata) facility that permits to define and use annotation types.
- The facility consists of:
  - a syntax for declaring annotation types
  - a syntax for annotating declarations
  - APIs for reading annotations
  - a class file representation for annotations
  - an annotation processing tool

Annotation Usage

- Annotations have a number of uses, among them:
  - **Information for the compiler** - Annotations can be used by the compiler to detect errors or suppress warnings
  - **Compiler-time and deployment-time processing** - Software tools can process annotation information to generate code, XML files, and so forth
  - **Runtime processing** - Some annotations are available to be examined at runtime (reflection)

What can be annotated?

Annotatable program elements:

- package
- class, including
  - interface
  - enum
- method
- field
- only at compile time
  - local variable
  - formal parameter

Annotations Used by the Compiler

- There are three annotation types that are predefined by the language specification itself:
  - `@Deprecated` – indicates that the marked element is deprecated and should no longer be used
  - `@Override` – informs the compiler that the element is meant to override an element declared in a superclass
  - `@SuppressWarnings` – tells the compiler to suppress specific warnings that it would otherwise generate

Inheritance

INHERITANCE

- Inheritance denotes Specialization.
- A *subclass* is a class that extends another class. A subclass inherits state and behavior from all of its ancestors (a.k.a super class(es)).
- A subclass inherits variables and methods from its superclass and all of its ancestors. The subclass can use these members as is, or it **can hide** the member variables or **override** the methods.

Constructors in inheritence

- While creating subclass objects super class default constructor is automatically invoked
- To invoke arguemented constructor of super class use super() with arguments
- super() should be first statement in subclass constructor

Overriding

- Overriding a method means replacing the superclass's implementation of a method with one of your own. The signature must be identical
- When a method is overridden it means both the signature and return type are SAME as in the superclass.
- If two methods differ only in return type it is an ERROR and the compiler will reject the class.

Overriding (cont…)

- Overriding methods can have their own access specifiers. A subclass can change the access of a superclass's methods, but ONLY to provide MORE access.

- For example

```
class Base {
   Protected void show() {
   }
}
Class Derived extends Base{
   Public void show() {  //this is valid
   }
}
```

Overriding (cont…)

- The Overriding method can be made final but not the method being overridden.
- Overriding method's throws clause CAN BE different from that of the superclass method's as long as every exception type listed in the overriding method is the same or a subtype of the exceptions listed in the superclass's method.
- An overriding method can have **NO** throws clause though the method in superclass has.
- Static method **CANNOT** be overridden.

Polymorphism

- Super class refrence variable can hold sub class object
- When a overriden method is invoked on super class reference variables, the method of the object held by it is invoked

Polymorphism

Example :

```
class  Person  {
        public void display(){   system.out.println("Person");    }
}

class  Employee extends Person  {
        public void display(){   system.out.println("Employee Data");    }
}

class  Student extends Person  {
        public void display(){   system.out.println("Student Data");    }
}
```

Polymorphism

Example :

```
Person p ;

p  = new Person();
p.display();                    //  output :  Person

p = new employee();
p.display();                    // output  :  Employee Data

p = new Student();
p.display();                    // output : Student Data
```

Abstract methods & classes

- Methods whose design is not complete are called abstract methods
- Ex: public abstract void printIt(intx, String y);

- Class having abstract methods should be declared as abstract class
- Abstract class cannot be instantiated (cannot create objects)
- Abstract classes are for subclassing
- A class declared as abstract need not have abstract methods

final class

- Class declared as final cannot be extended
- final class cannot have abstract methods
- Ex:

```
public final class LastOne {
    --------
    --------

}
```

Interfaces

Introduction

- The fundamental unit of OO design is the *type.*
- *Interfaces* define types in an abstract form as a collection of methods.
- *Interfaces* contain no implementation and you cannot create instances of an interface.
- Classes can expand their own types by implementing interfaces.

Introduction (contd…)

- Classes can implement more than one interface.

- In a given class, the classes that are extended and the interfaces that are implemented are collectively called the *supertypes*, the new class is a *subtype*.

Interface example

- An example of a simple interface :

```
public interface Comparable {
 int compareTo(Object o);
}
```

Declarations

- An *interface* is declared using the keyword interface, giving the interface a name and listing the interface members between braces.

- An interface can have
  1. Constants
  2. Methods (only signature)

- Interface members are implicitly *public*.

Interface constants

- An interface can declare named constants.
- These constants are *implicitly public, static, and final*.
- ```
  interface Verbose   {
     int SILENT = 0;
     int NORMAL = 1;
     int VERBOSE = 3;
  }
  ```
  ```

Interface methods

- The methods declared in an interface are implicitly abstract and public, no other modifiers are permitted
- Methods cannot be *static* – because static methods cannot be abstract.

Extending interfaces

- Interfaces can be extended using the extends keyword.

```
public interface SerializableRunnable
  extends Serializable, Runnable {
   //…….
   }
```

- The interfaces that are extended are the *superinterfaces* and the new interface is a *subinterface*

Implementing interfaces

- A class can implement one or more interfaces using *implements* keyword
- `public class XXXX implements Comparable {`

```
    public int compareTo(Object o )
        // Implementation details
}
```

Marker interfaces

- Some interfaces do not declare any methods. These are marker interfaces.
- Marker interfaces simply mark a class as having some general property.
- `Examples of marker interfaces:`
  - `Serializable`
  - `Cloneable`
  - `java.rmi.Remote`

Packages

- Packages are convenient ways of grouping related classes according to their functionality, usability as well as category they should belong to.
- Classes under different packages **CAN HAVE** same names.
- Packaging help us to avoid class name collision when we use the same class name as that of others

How to create Packages?

1. Suppose we have a file called **HelloWorld.java**, and we want to put this file in a package **world** then add the package definition in the top of the file as shown below…

```
// only comment are allowed before this definition
package world;
public class HelloWorld {
//…

}
```

2. Create subdirectories to represent package hierachy of the class. In our case, we have the **world** package, which requires only one directory. So, we create a directory **world** and put our HelloWorld.java into it.

How to use Packages?

- There are 2 ways in order to use the public classes stored in package.

1. Declare the fully-qualified class name. For example,

```
world.HelloWorld hw = new world.HelloWorld();
world.moon.HelloMoon hm = new world.moon.HelloMoon();
String holeName = helloMoon.getHoleName();
```

2. Use an "import" keyword:

```
import world.*;
import world.moon.*;
HelloWorld helloWorld = new HelloWorld();
HelloMoon helloMoon = new HelloMoon();
```

CLASSPATH

- Environment variable CLASSPATH should be set to search for packages
- Specify a series of folders in classpath
- Ex:

  Set CLASSPATH=c:\;d:\javaprg;c:\test\classes
- Packages / classes are searched for in c:\ , d:\javaprg and c:\test\classes in that order
- Classes with no package statement belong to default package

Using Access Control

- There are four access levels that can be applied to data fields and methods. The following table illustrates access to a field or a method marked with the access modifier in the left column.

Modifier (keyword)	Same Class	Same Package	Subclass in Another Package	Universe
`private`	Yes			
`default`	Yes	Yes		
`protected`	Yes	Yes	Yes *	
`public`	Yes	Yes	Yes	Yes

Points to Note

- Classpath not required for JDK classes
- While using JDK classes, package to which the class belongs should be identified for import statement
- java.lang package classes need not be imported
- Object, String, StringBuffer, Runtime, System classes and wrapper classes belong to java.lang package

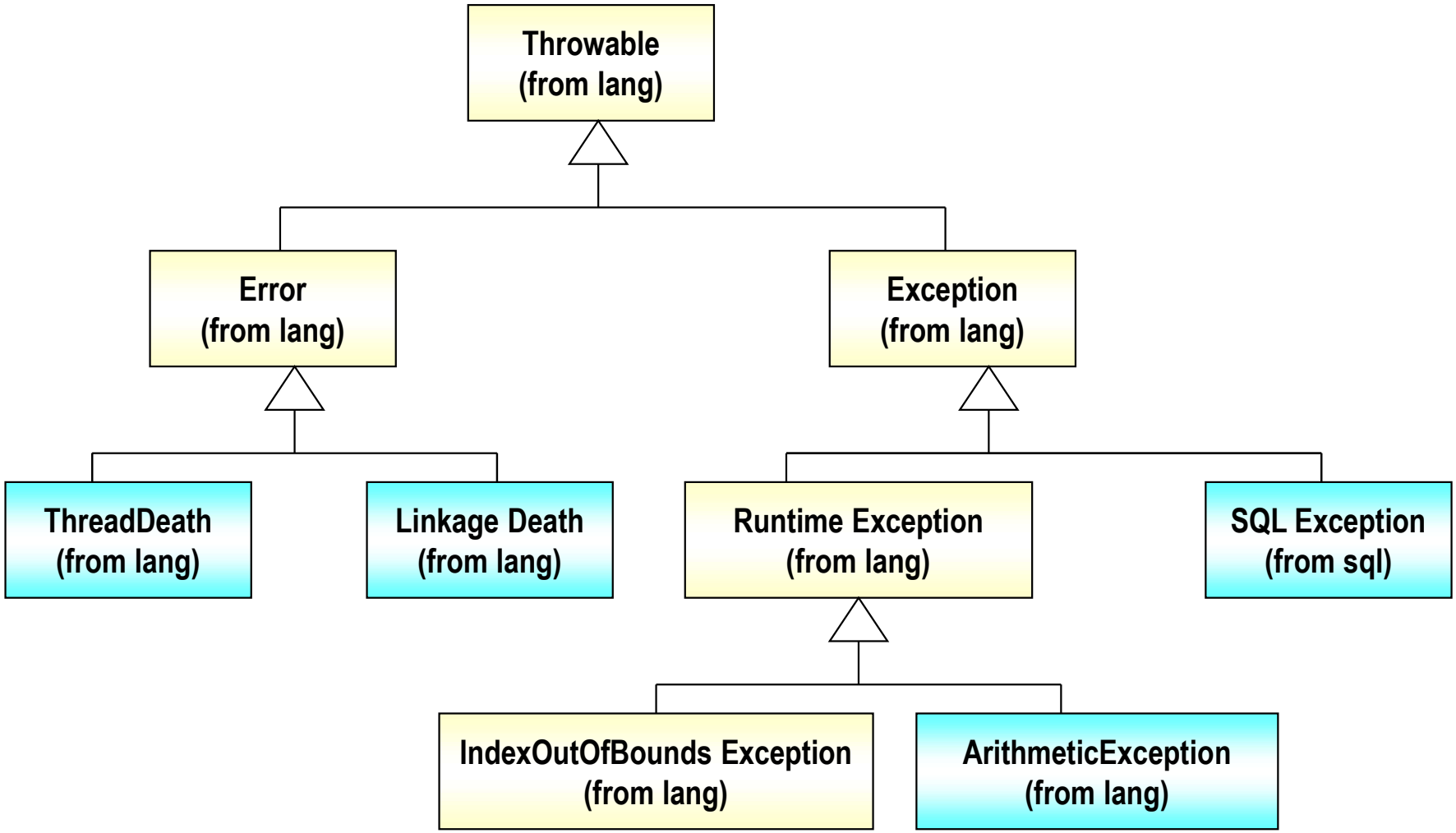
Exceptions

Exception Handling

- Exception is an event that occurs during the execution of a program that disrupts the normal flow of instructions

- Exceptions can occur when
  - The file you try to open does not exist
  - The network connection is disrupted
  - Operands being manipulated are out of prescribed ranges
  - The class files you are interested in loading are missing

Exception class hirarchy



Exception Handling

- Checked Exceptions
  - Extends the java.lang.Exception class.
  - Needs to be caught or specified.
- Unchecked Exceptions
  - Extends the java.lang.RuntimeException class
  - Need not be caught or specified.

Exception Handling

- Methods should either catch or specify all checked exceptions that can be thrown within the scope of that method
- A method can catch an exception by providing an exception handler for that type of exception
- If a method chooses not to catch an exception, the method must specify that it can throw that exception
- Callers of a method must know about the exceptions that a method can throw

Dealing with Exceptions

- Three components of an exception handler

  try, catch, and finally blocks

try Block

- Enclose the statements that might throw an exception within a try block
- Defines the scope of any exception handlers

catch Block

- Associate exception handlers with a try block by providing one or more catch blocks directly after the try block

finally Block

- Allows the method to clean up after itself regardless of what happens within the try block

Exceptions - example

```
public void writeList() {
    PrintWriter out = null;
    try {
            System.out.println("Entering try statement");
            out = new PrintWriter(
                      new FileWriter("OutFile.txt"));

            for (int i = 0; i < size; i++)
                out.println("Value at: " + i + " = " +
      victor.elementAt(i));
       } catch (ArrayIndexOutOfBoundsException e) {
            System.out.println("Array referror " + e.getMessage());
       } catch (IOException e) {
            System.out.println("IOException: " + e.getMessage());
       }
       finally {
            if (out != null)
                out.close();
       }
   }
```

Specifying the Exceptions Thrown by a Method

- To let a method transfer the exception to the caller, specify throws
- Caller is responsible to handle this exception

Ex:

```
public void writeList() throws IOException {
    PrintWriter pw =
          new PrintWriter(new FileWriter("File.txt"));
          for (int i = 0; i < size; i++)
                pw.println(b[i]);
          pw.close();
    }
```

Defining Exceptions

throw statement

Before you can catch an exception, some Java code somewhere must throw one

```
throw someThrowableObject;
```

Throwable objects should be subclass of the Throwable class

Defining Exceptions - example

```
public class ApplicationException extends Exception{
   public ApplicationException(String msg){
          super(msg);
   }
}

public void readFile(String fileName) throws
   ApplicationException {
try {
   FileInputStream fis = new FileInputStream(fileName);
      …….
   }
   catch (FileNotFoundException e) {
      throw new ApplicationException("File Not Found",
      e);
   }
}
```

Classes of java.lang package

Object class

- Every java class extends Object class either directly or indirectly
- Object class provides useful methods required in every class
- Some of the methods need to be overwritten
- If a class does not extend any class, it automatically extends Object
- Every java objet is instanceof Object

Object class

Some Object class methods

boolean equals (Object obj)

Decides whether two objects are meaningfully equivalent.

void finalize( )

Called by garbage collector when the garbage collector sees that the object cannot be referenced

int hashCode( )

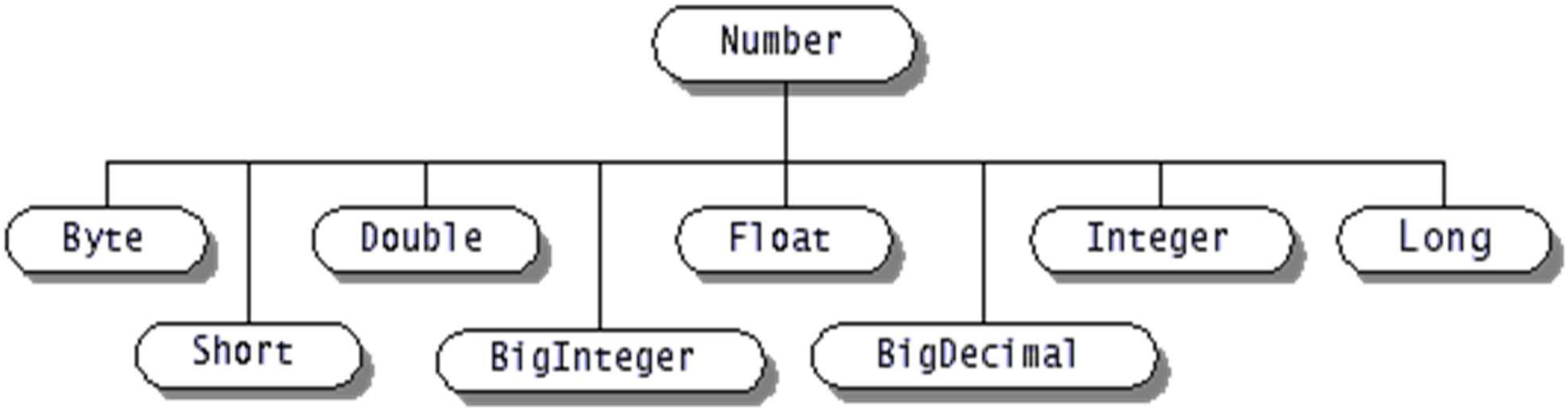
Returns a hashcode int value for an object, so that the object can be used in Collection classes that use hashing, including Hashtable, HashMap, and HashSet

String toString( )

Returns a “text representation” of the object

Wrapper classes

- Wrapper classes available to create objects for all primitive types
- These classes provide methods to convert wrap primitive types and also convert back to primitives



- Also available, Boolean and Character classes

Wrapper classes

- Designed to convert primitives into objects
- Wrapper objects are immutable
- provide functions for conversion of primitives to/from String objects to different bases
- All wrapper class names map to primitives they represent except Integer and Character
- Byte, Short, Integer, Long, Float, Double are sub classes of Number
- constructors overloaded to take primitives as well as their String representation

Wrapper classes

- Common methods of wrapper classes

Methods of Number

```
byte    byteValue( )
short   shortValue( )
int     intValue( )
long    longValue( )
float   floatValue( )
double  doubleValue( )
```

Character

```
char charValue( )
```

Boolean

```
boolean booleanValue( )
```

Auto Boxing Unboxing

- Before Java 5, wrapping and unwrapping was done explicitly
- For example to perform arithmatic on a wrapped value involved unwrapping and re-wrapping after operation

```
Integer  x = new Integer(45);
int y = x.intValue( );
y = y +10 ;
x = new Integer(y) ;
```

- java 5 provides auto boxing / unboxing
- In that wrapping and unwrapping done automatically based on the operation

```
Integer  x = 45;
x  = x +10 ;
x++;   // and so on
```

Auto Boxing Unboxing

All these are possible now !!!

```
Integer  x = 36;    // wrap it
x++;                // unwrap and re-wrap

List l = new ArrayList();
 l.add(0,36);       //wrap and add

Integer a = 30;    //wrap
Integer b = 20;    //wrap
Integer c = a + b;     //unwrap, add, wrap the sum

if (a.equals(30) )    //unwrap and compare
```

Math class

- Math class provides many arithmatic, trignometric and logarithmic methods
- All these methods are static
- It is not possible to creat Math class object
- Example methods:

  static double sqrt(double)

  static double sin(double)

  static double random( )

Date and time handling

- An instance of java.util.Date represents a specific instant in time with millisecond precision
- java.util.Calendar is an abstract base class for extracting detailed information such as year, month, date, hour, minute and second from a Date object
- Subclasses of Calendar can implement specific calendar systems such as Gregorian calendar, Lunar Calendar and Jewish calendar
- Currently, java.util.GregorianCalendar for the Gregorian calendar is supported in the Java API
- You can use new GregorianCalendar() to construct a default GregorianCalendar with the current time
- use new GregorianCalendar(year, month, date) to construct a GregorianCalendar with the specified year, month, and date. The month parameter is 0-based, i.e., 0 is for January

Date and time handling

- **Calendar.getInstance()** returns current date
- **getTime()** of Calendar object returns Date object
- **get(field)** method of calendar object returns individual elements of the date&time
- **add(field, number)** method of calendar object can be used to perform date calculations
- **set(y,m,d)** of calendar object can be used to change field values
- **set(field,value)** of calendar object used to change any field value

Calendar - Examples

```
SimpleDateFormat sdf = new SimpleDateFormat(“dd/MMM/yyyy");
Calendar cal = new GregorianCalendar(2013,0,31);
System.out.println(sdf.format(cal.getTime()));

cal.set(2010, 6, 21);
System.out.println(sdf.format(cal.getTime()));

Calendar calendar = Calendar.getInstance();

int year          = calendar.get(Calendar.YEAR);
int month         = calendar.get(Calendar.MONTH);    // Jan = 0, dec = 11
int dayOfMonth    = calendar.get(Calendar.DAY_OF_MONTH);
int dayOfWeek     = calendar.get(Calendar.DAY_OF_WEEK);
int weekOfYear    = calendar.get(Calendar.WEEK_OF_YEAR);
int weekOfMonth= calendar.get(Calendar.WEEK_OF_MONTH);

calendar.add(Calendar.MONTH, 1);
calendar.add(Calendar.DAY_OF_MONTH, -10);
```

Working with Local Date and Time

- The `java.time` API defines two classes for working with local dates and times (without a time zone):
  - `LocalDate`:
    - Does not include time
    - A year-month-day representation
    - `toString` – ISO 8601 format (YYYY-MM-DD)
  - `LocalTime`:
    - Does not include date
    - Stores hours:minutes:seconds.nanoseconds
    - `toString` – (HH:mm:ss.SSSS)

`LocalDate`: Example

```
import java.time.LocalDate;
import static java.time.temporal.TemporalAdjusters.*;
import static java.time.DayOfWeek.*;
import static java.lang.System.out;

public class LocalDateExample {

  public static void main(String[] args) {
    LocalDate now, bDate, nowPlusMonth, nextTues;
    now = LocalDate.now();
    out.println("Now: " + now);
    bDate = LocalDate.of(1995, 5, 23); // Java's Birthday
    out.println("Java's Bday: " + bDate);
    out.println("Is Java's Bday in the past? " + bDate.isBefore(now));
    out.println("Is Java's Bday in a leap year? " + bDate.isLeapYear());
    out.println("Java's Bday day of the week: " + bDate.getDayOfWeek());
    nowPlusMonth = now.plusMonths(1);
    out.println("The date a month from now: " + nowPlusMonth);
    nextTues = now.with(next(TUESDAY));
    out.println("Next Tuesday's date: " + nextTues);
  }
}
```

`next` method

`TUESDAY`

`LocalDate` objects are immutable – methods return a new instance.

Working with `LocalTime`

`LocalTime` stores the time within a day.

- Measured from midnight
- Based on a 24-hour clock (13:30 is 1:30 PM.)
- Questions you can answer about time with `LocalTime`
  - When is my lunch time?
  - Is lunch time in the future or past?
  - What is the time 1 hour 15 minutes from now?
  - How many minutes until lunch time?
  - How many hours until bedtime?
  - How do I keep track of just the hours and minutes?

LocalTime: Example

```
import java.time.LocalTime;
import static java.time.temporal.ChronoUnit.*;
import static java.lang.System.out;

public class LocalTimeExample {
  public static void main(String[] args) {
    LocalTime now, nowPlus, nowHrsMins, lunch, bedtime;
    now = LocalTime.now();
    out.println("The time now is: " + now);
    nowPlus = now.plusHours(1).plusMinutes(15);
    out.println("What time is it 1 hour 15 minutes from now? " + nowPlus);
    nowHrsMins = now.truncatedTo(MINUTES);
    out.println("Truncate the current time to minutes: " + nowHrsMins);
    out.println("It is the " + now.toSecondOfDay()/60 + "th minute");
    lunch = LocalTime.of(12, 30);
    out.println("Is lunch in my future? " + lunch.isAfter(now));
    long minsToLunch = now.until(lunch, MINUTES);
    out.println("Minutes til lunch: " + minsToLunch);
    bedtime = LocalTime.of(21, 0);
    long hrsToBedtime = now.until(bedtime, HOURS);
    out.println("How many hours until bedtime? " + hrsToBedtime);
  }
}
```

HOURS, MINUTES

Prefix	Example	Use
`now`	`today = LocalDate.now()`	Creates an instance using the system clock
`of`	`meet = LocalTime.of(13, 30)`	Creates an instance by using the parameters passed
`get`	`today.get(DAY_OF_WEEK)`	Returns part of the state of the target
`with`	`meet.withHour(12)`	Returns a copy of the target object with one element changed
`plus, minus`	`nextWeek.plusDays(7)` `sooner.minusMinutes(30)`	Returns a copy of the object with the amount added or subtracted
`to`	`meet.toSecondOfDay()`	Converts this object to another type. Here returns `int` seconds.
`at`	`today.atTime(13, 30)`	Combines this object with another; returns a `LocalDateTime` object
`until`	`today.until`	Calculates the amount of time until another date in terms of the unit
`isBefore, isAfter`	`today.isBefore(lastWeek)`	Compares this object with another on the timeline
`isLeapYear`	`today.isLeapYear()`	Checks if this object is a leap year

Period

- `Period` is a class that holds a date-based amount.
  - Years, months, and days based on the ISO-8601 calendar
  - Plus and minus work with a conceptual day, thus preserving daylight savings changes

```
Period oneDay = Period.ofDays(1);
System.out.println("Period of one day: " + oneDay);
LocalDateTime beforeDST = LocalDateTime.of(2014, MARCH, 8, 12, 00);
ZonedDateTime newYorkTime =
   ZonedDateTime.of(beforeDST, ZoneId.of("America/New_York"));
System.out.println("Before: " + newYorkTime);
System.out.println
newYorkTime.plus(oneDay));
```

The time is preserved, because only "days" are added.

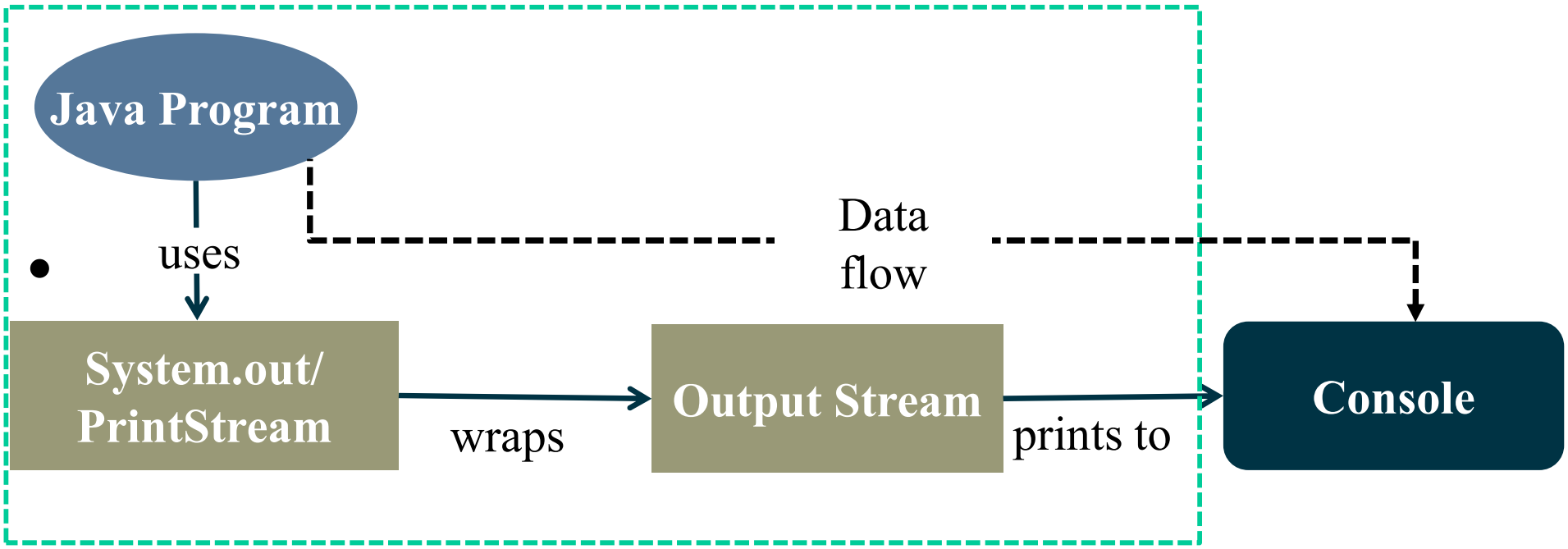
```
Period of one day: P1D
```

Console I/O

The `System` class in the `java.lang` package has three static instance fields: `out`, `in`, and `err`.

- The `System.out` field is a static instance of a `PrintStream` object that enables you to write to *standard output.*
- The `System.in` field is a static instance of an `InputStream` object that enables you to read from *standard input.*
- The `System.err` field is a static instance of a `PrintStream` object that enables you to write to *standard error.*

Console output



These are statements for displaying simple text messages to the user.

System.out.print("Welcome to Codington")
System.out.println ("Welcome to Codington")

Console Input Using the `Scanner` Class

- Starting with version 5.0, Java includes a class for doing simple keyboard input named the **`Scanner`** class
- The following line creates Scanner object linked to keyboard

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

- Once a **`Scanner`** object has been created, a program can then use that object to perform keyboard input using methods of the **`Scanner`** class

Console Input Using the **`Scanner`** Class

- The method **`nextInt`** reads one **`int`** value typed in at the keyboard and assigns it to a variable:

```
int num = scan.nextInt();
```

- The method **`nextDouble`** reads one **`double`** value typed in at the keyboard and assigns it to a variable:

```
double d1 = scan.nextDouble();
```

- Similarly, it has methods for all other data types

next()	for String
nextLong()	for long value
nextShort()	for short value
…… etc	

Console Input Using the **`Scanner`** Class

- The method **`nextLine`** reads an entire line of keyboard input
- The code

```
String line = next.nextLine();
```

reads in an entire line and places the string that is read into the variable line

Command line arguments

- To supply data while starting the program we can send command line arguments
- example :

```
java MyProgram string1 string2 string3
```

- These values (string1, string2, string3) will be supplied to the main function as String array
- Example:

```
public static void main (String [] args) {  }
```

Using the command line

- However, we can give this array values by providing command line arguments when we start a program running

```
java MyProgram string1  string2  string3

                 args[0]  args[1]  args[2]
```

- To know the number of arguments we can use **args.length**
- For numeric data we have to parse the strings into corresponding data types

Using the command line

- Sample program:

```
public class Echo {
   public static void main(String [] args) {
       System.out.println("first value: " + args[0]);
       System.out.println("second value: " + args[1]);
   }
}
```

```
java Echo Amir Khan
first value: Amir
second value: Khan
```

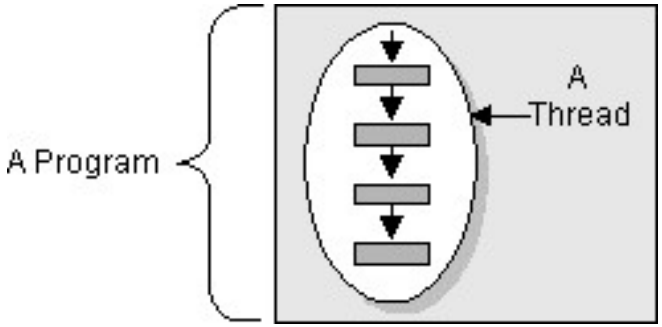
Multi Thread Programming

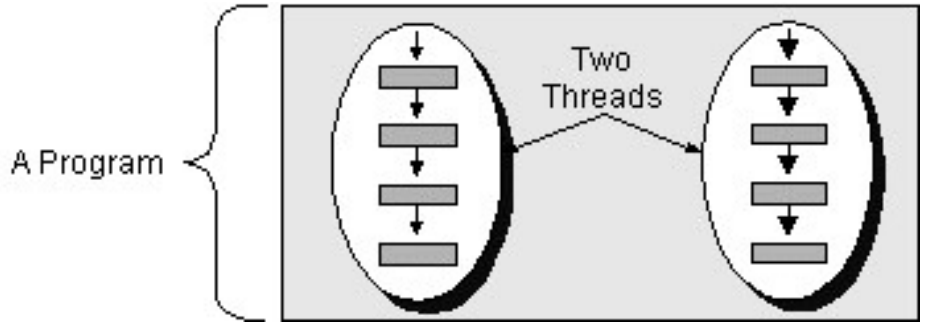
What is Multithreading?

- In multithreading, the thread is the smallest unit of code that can be dispatched by the thread scheduler
- A single program can perform two tasks using two threads
- Only one thread will be executing at any given point of time given a single-processor architecture

Threads

A thread is a single sequential flow of control within a program





Threads

- **A thread is an object of type Thread defined in java.lang package**

- **Multi-threading functionality in Java is supported in four places**
  - **Thread class**
  - **Runnable interface**
  - **Object class**
  - **Java virtual machine**

- **There are two ways to create a "Thread"**
  - **Subclassing Thread and provide run() method**
  - **Implementing the Runnable Interface**

The Thread class

- Java's multithreading feature is built into the **Thread** class

- The **Thread** class has two primary thread control methods:

  public void start() - The **start()** method starts a thread execution

  public void run() - The **run()** method actually performs the work of the thread and is the entry point for the thread

- The thread *dies* when the **run( )** method terminates
- You never call **run( )** explicitly
- The **start( )** method called on a thread automatically initiates a call to the thread's **run( )** method

Extending Thread

- Instantiate the class that extends Thread
- This class must override run() method
- The code that should run as a thread will be part of this run() method
- We must call the start() method on this thread
- start( ) in turn calls the thread's run( ) method

Extend Thread - Example

```
public class SimpleThread extends Thread {
      public SimpleThread(String str) {
         super(str);
      }
      public void run() {
          for (int i = 0; i < 10; i++) {
              System.out.println(i);
              try {
                  sleep((long)(Math.random() * 1000));
              } catch (InterruptedException e) {}
          }
          System.out.println("DONE! “);
      }
}
```

Activating the thread

```
SimpleThread tt = new SimpleThread(“thread 1”);
tt.start();
```

Implementing Runnable

- Create a class, which must implement the **interface Runnable**
- A thread can be constructed on any object that implements the **Runnable** interface.
- To implement **Runnable**, a class need implement only a single method called **run( )**

- After defining the class that implements Runnable, we have to create an object of type Thread passing the Runnable object to Thread constructor.

- This is mandatory because a thread object confers multithreaded functionality to the object from which it is created.

- Therefore, at the moment of thread creation, the thread object must know the reference of the object to which it has to confer multithreaded functionality.

Implementing Runnable - Example

```
public class SimpleThread implements Runnable {
        String name ;
        public SimpleThread(String str) {
            name = str;;
        }
        public void run() {
            for (int i = 0; i < 10; i++) {
                System.out.println(i);
                try {
                    sleep((long)(Math.random() * 1000));
                } catch (InterruptedException e) {}
            }
            System.out.println("DONE! ");
        }
}
```

Activating the thread

```
SimpleThread st = new SimpleThread("Thread 1");
Thread tt = new Thread(st);
tt.start();
```

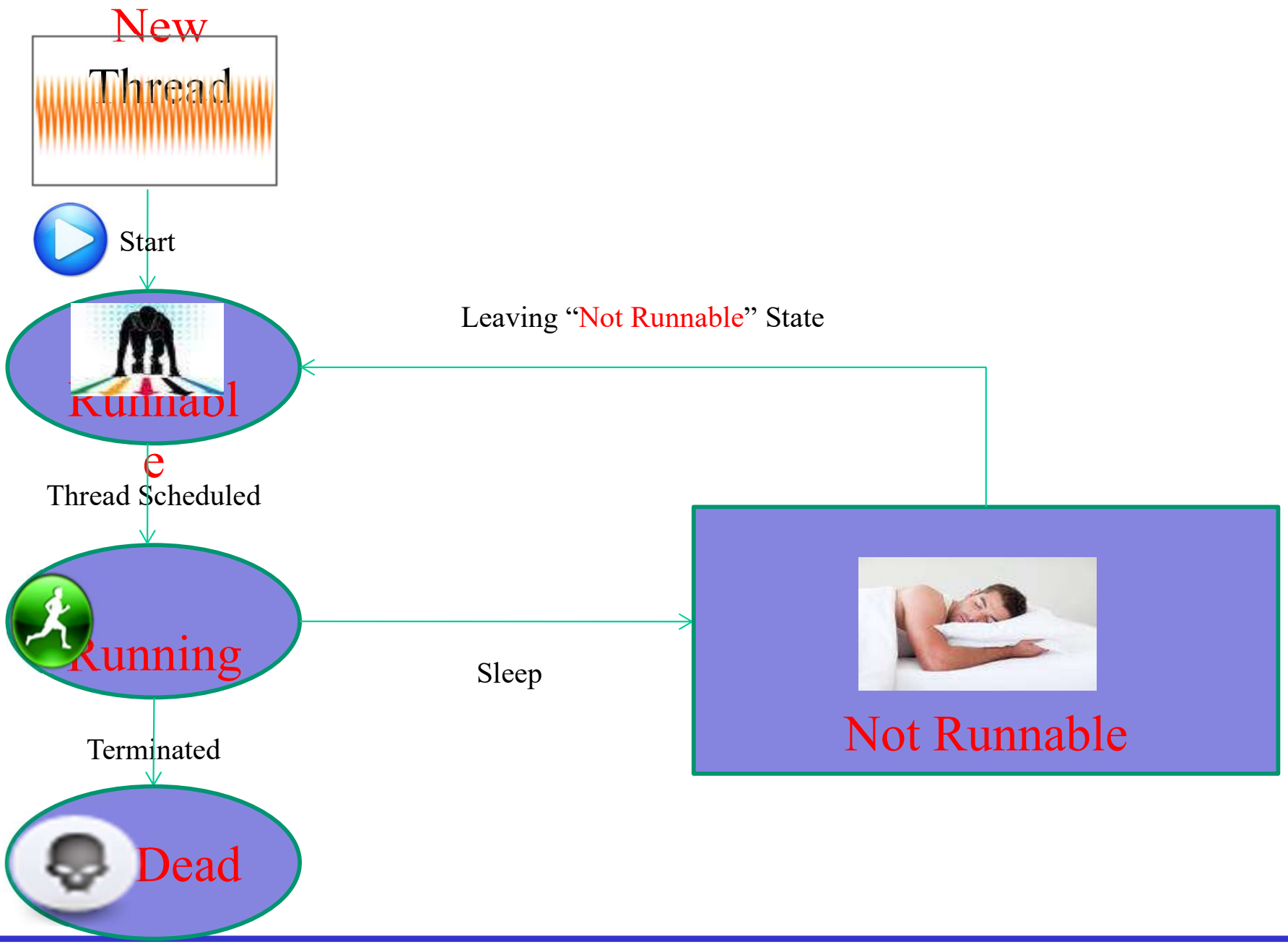
Control Thread Execution

- Two ways exist by which you can determine whether a thread has finished:

- The **isAlive( )** method will return true if the thread upon which it is called is still running; else it will return false

- The **join( )** method waits until the thread on which it is called terminates.

Different States of a Thread



Synchronization

- It is normal for threads to be sharing objects and data
- Different threads shouldn't try to access and change the same data at the same time
- Threads must therefore be synchronized
- For example, imagine a Java application where one thread deleting characters in a StringBuffer object, while a second thread inserting characters at the same place of the StringBuffer object

Synchronization

- The current thread operating on the shared data structure, must be granted mutually exclusive access to the data
- The current thread gets an exclusive lock on the shared data structure, or a **mutex**
- A **mutex** is a concurrency control mechanism used to ensure the integrity of a shared data structure

Synchronized Methods

- Synchronized methods are an elegant way of locking the object
- Implementation of concurrency control mechanism is very simple because every Java object has its own implicit monitor associated with it
- If a thread wants to enter an object's monitor, it has to just call the synchronized method of that object
- While a thread is executing a synchronized method, all other threads that are trying to invoke that particular synchronized method or any other synchronized method of the same object, will have to wait

Synchronization

- Every object in Java has a lock
- Using *synchronization* enables the lock and allows only one thread to access that part of code
- Synchronization can be applied to:
  - A method

    public synchronized void withdraw(){…}
  - A block of code

    synchronized (objectReference){…}
- Synchronized methods in subclasses use same locks as their superclasses

Thread Messaging

- In Java, you need not depend on the OS to establish communication between threads
- All objects have predefined methods, which can be called to provide inter-thread communication

Inter-Thread Communication

- Threads are often interdependent - one thread depends on another thread to complete an operation, or to service a request.
- The words wait and notify encapsulate the two central concepts to thread communication
  - A thread waits for some condition or event to occur.
  - You notify a waiting thread that a condition or event has occurred.
- To avoid polling, Java's elegant inter-thread communication mechanism uses:
  - wait( )
  - notify( ), and notifyAll( )

Inter-Thread Communication (Contd.).

- wait( ), notify( ) and notifyAll( )
  - Are declared as final in Object
  - Hence, these methods are available to all classes
  - These methods can only be called from a synchronized context

- wait( ) directs the calling thread to surrender the monitor, and go to sleep until some other thread enters the monitor of the same object, and calls notify( )

- notify( ) wakes up the other thread which was waiting on the same object(*that had called wait() previously on the same object*)

Inter-Thread Communication - example

```
public class MessageBox {
    String message=null;
    synchronized String get() {
        if (message==null)
            try {
            wait();
            } catch (InterruptedException e) {
                System.out.println("InterruptedException caught");
            }
        String newMessage=message;
        message=null;
        notify();
        return newMessag;
    }
```

Inter-Thread Communication - example

```
synchronized void put(String message) {
        if (this.message != null)
                try {
                        wait();
                } catch (InterruptedException e) {
                        System.out.println("InterruptedException caught");
                }
        this.message = message;
        System.out.println("Put: " + message);
        notify();
    }
}
```

Inter-Thread Communication - example

```
public class Consumer implements Runnable {
        MessageBox box;

    public Consumer(MessageBox box) {
            this.box = box;
    }

    public void run() {
            int i = 0;
            while (++i < 6) {
                    String msg=box.get();
                    System.out.println("Got "+msg);
            }
    }
}
```

Inter-Thread Communication - example

```
Public class Producer implements Runnable {
    MessageBox myBox;

    Producer(MessageBox box) {
        myBox = box;
    }

    public void run() {
        int i = 0;
        while (++i <6) {
            myBox.put("Message " + i);
        }
    }
}
```

Inter-Thread Communication - example

```
public class Main {

    public static void main(String args[]) {
        MessageBox box = new MessageBox();
        Producer prod = new Producer(box);
        Consumer con = new Consumer(box);
        new Thread(con).start();
        new Thread(prod).start();
    }
}
```

DeadLock

- A simple deadlock situation is one in which a two threads are waiting
- Each thread waiting for a resource which is held by the other waiting thread
- this resource is usually the object lock obtained by the synchronized keyword

DeadLock - Example

```
class Account {
 private int id;
 private int balance;

 public void deposit(int amount) {
   this.balance += amount;
 }

 public  void withdraw(int amount) {
   this.balance -= amount;
 }

 public static void transfer(Account from, Account to, int amount) {
   synchronized (from) {
     synchronized (to) {
       from.withdraw(amount);
       to.deposit(amount);
     }
   }
}
```