Session 06
Numbers and Strings

(http://docs.oracle.com/javase/tutorial/java/data/index.html)
(https://docs.oracle.com/javase/8/docs/)
(http://www.oracle.com/technetwork/java/javase/documentation/jdk8-doc-downloads-2133158.html)

Objectives

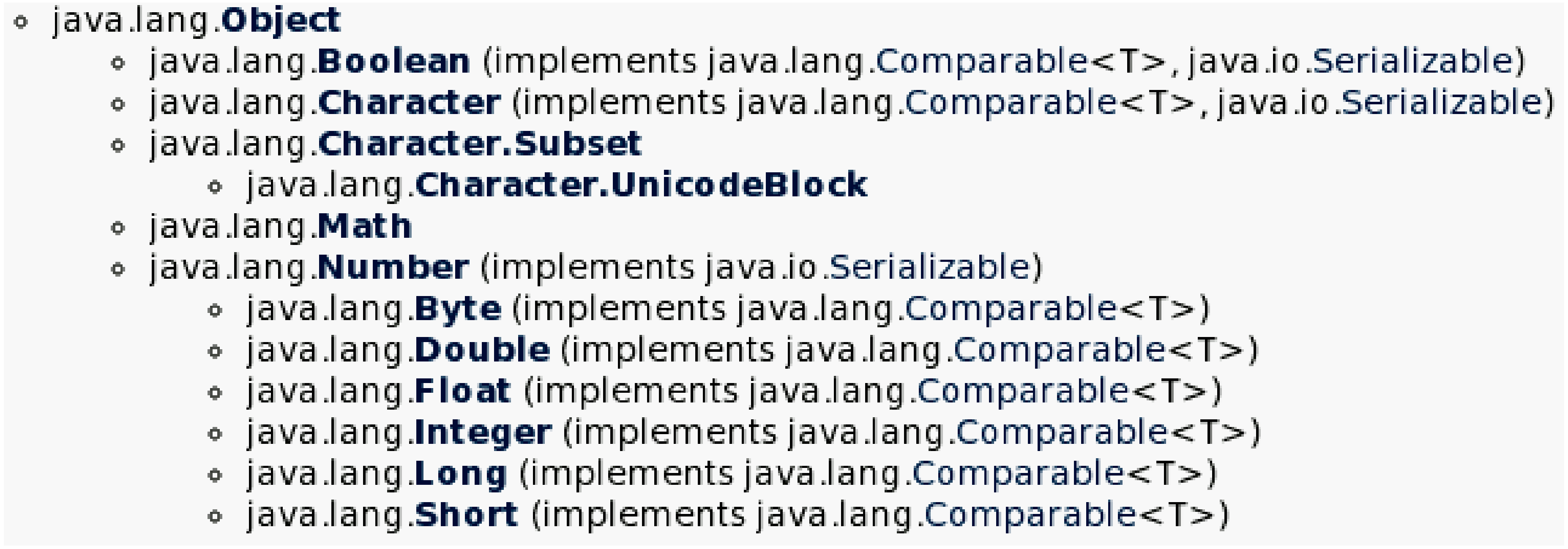
- **Working with Numbers**:
  - Wrapper classes: Number, Character
  - Auto boxing and unboxing .
- **The java.lang.Math**
- **String class**:
  - Create and manipulate strings.
  - Compares the String and StringBuilder classes.
- **Scanning Text**
- **Formatting output**

Introduction

- A class can contain no data field or some data fields
- Some operations on numbers are critical such as converting a string to number, …
- Java libraries have classes which wrap a number (primitive type) in it and support operations on numbers. They are called as wrapper classes.
- String is a common data type and it is a pre-defined class in Java library.
- The **java.lang** package contains all of them

Numbers Classes

- Java platform provides *wrapper* classes for each of the primitive data types.

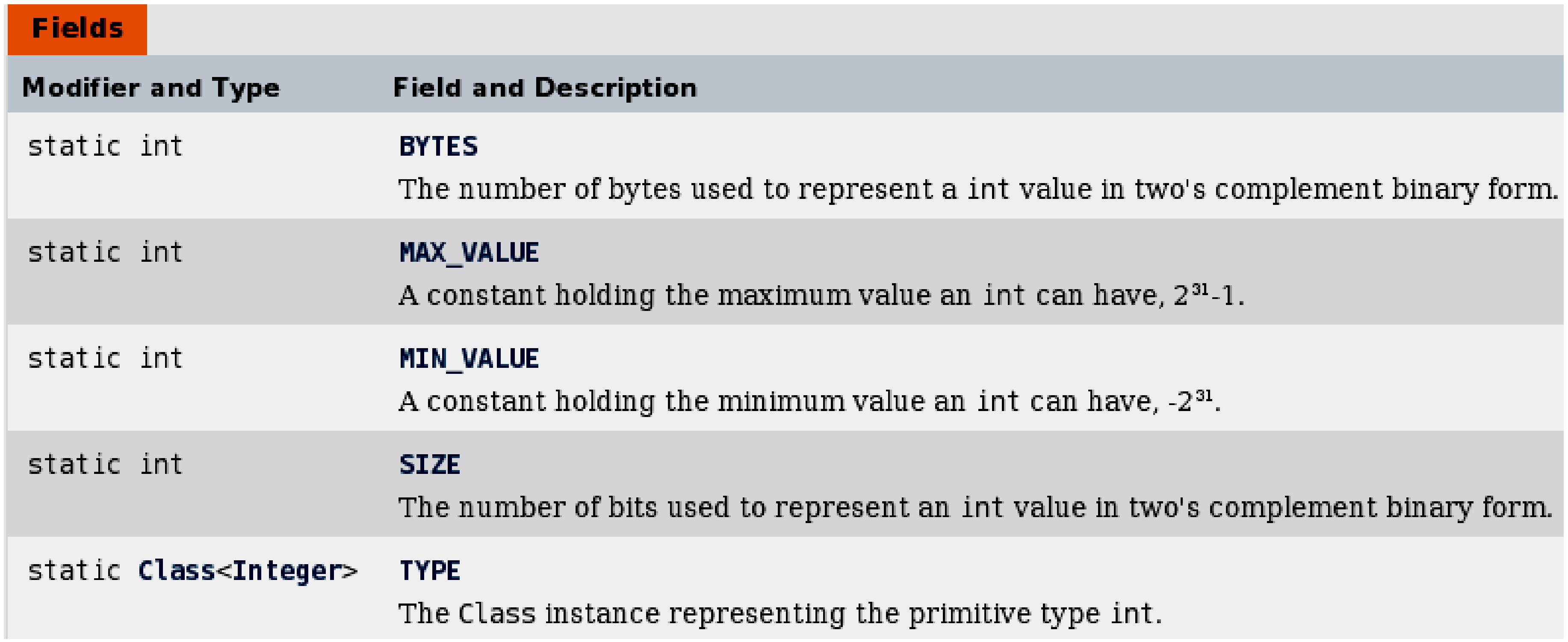


- java.lang.**Object**
  - java.lang.**Boolean** (implements java.lang.Comparable<T>, java.io.Serializable)
  - java.lang.**Character** (implements java.lang.Comparable<T>, java.io.Serializable)
  - java.lang.**Character.Subset**
    - java.lang.**Character.UnicodeBlock**
  - java.lang.**Math**
  - java.lang.**Number** (implements java.io.Serializable)
    - java.lang.**Byte** (implements java.lang.Comparable<T>)
    - java.lang.**Double** (implements java.lang.Comparable<T>)
    - java.lang.**Float** (implements java.lang.Comparable<T>)
    - java.lang.**Integer** (implements java.lang.Comparable<T>)
    - java.lang.**Long** (implements java.lang.Comparable<T>)
    - java.lang.**Short** (implements java.lang.Comparable<T>)

All of the numeric wrapper classes are subclasses of the abstract class Number.

Numbers Classes: A Declaration

public final class Integer extends Number implements Comparable<Integer>



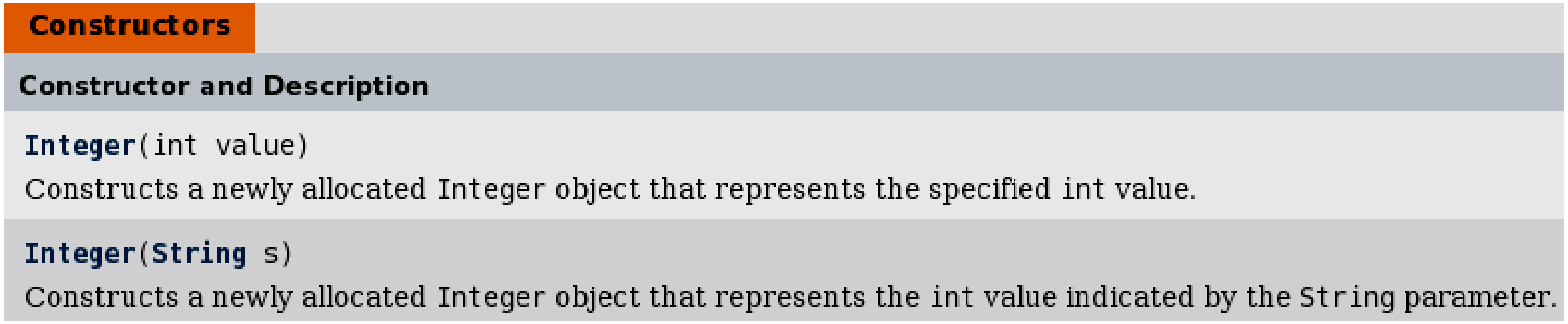
Fields

Modifier and Type	Field and Description
`static int`	**BYTES** The number of bytes used to represent a `int` value in two's complement binary form.
`static int`	**MAX_VALUE** A constant holding the maximum value an `int` can have, 2^{31}-1.
`static int`	**MIN_VALUE** A constant holding the minimum value an `int` can have, -2^{31}.
`static int`	**SIZE** The number of bits used to represent an `int` value in two's complement binary form.
`static Class<Integer>`	**TYPE** The `Class` instance representing the primitive type `int`.

Numbers Classes: A Declaration

public final class Integer extends Number implements Comparable<Integer>

We can not create a sub-class of a wrapper class



Constructors

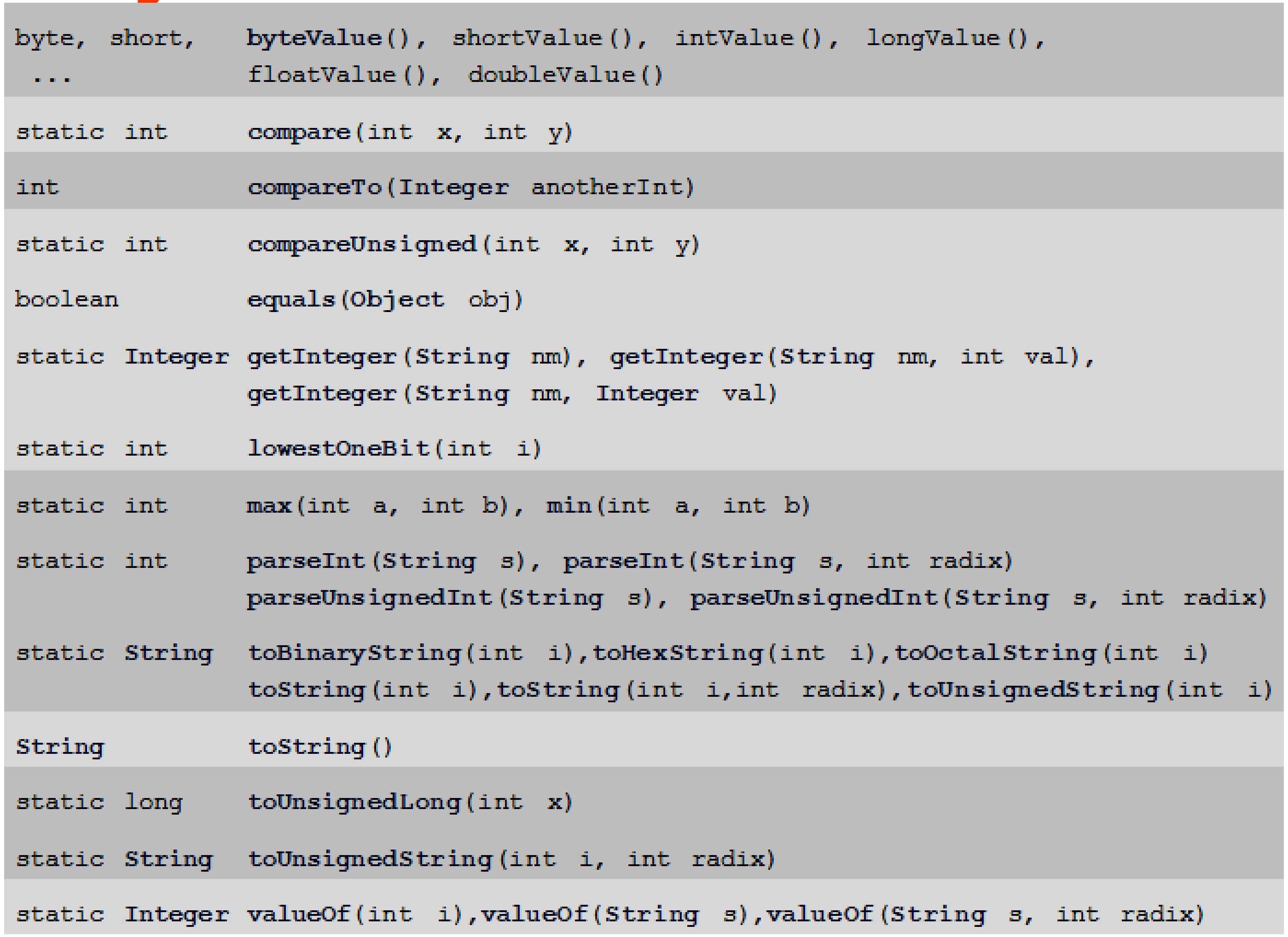
Constructor and Description
`Integer(int value)` Constructs a newly allocated `Integer` object that represents the specified `int` value.
`Integer(String s)` Constructs a newly allocated `Integer` object that represents the `int` value indicated by the `String` parameter.

Numbers Classes: A Declaration

public final class Integer extends Number implements Comparable<Integer>

Some common methods

Wrapper classes are immutable (non-changeable) because they do not have setters



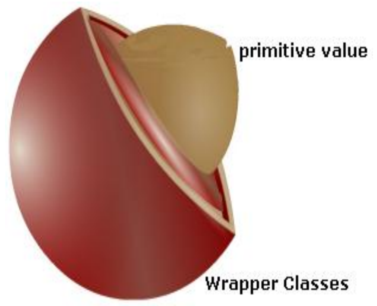
`byte, short, ...`	`byteValue(), shortValue(), intValue(), longValue(), floatValue(), doubleValue()`
`static int`	`compare(int x, int y)`
`int`	`compareTo(Integer anotherInt)`
`static int`	`compareUnsigned(int x, int y)`
`boolean`	`equals(Object obj)`
`static Integer`	`getInteger(String nm), getInteger(String nm, int val), getInteger(String nm, Integer val)`
`static int`	`lowestOneBit(int i)`
`static int`	`max(int a, int b), min(int a, int b)`
`static int`	`parseInt(String s), parseInt(String s, int radix) parseUnsignedInt(String s), parseUnsignedInt(String s, int radix)`
`static String`	`toBinaryString(int i),toHexString(int i),toOctalString(int i) toString(int i),toString(int i,int radix),toUnsignedString(int i)`
`String`	`toString()`
`static long`	`toUnsignedLong(int x)`
`static String`	`toUnsignedString(int i, int radix)`
`static Integer`	`valueOf(int i),valueOf(String s),valueOf(String s, int radix)`

Numbers Classes…

- We use a Number object rather than a primitive when:
  - As an argument of a method that expects an object.
  - To use constants defined by the class, such as MIN_VALUE and MAX_VALUE.
  - To use class methods for converting values to and from other primitive types.

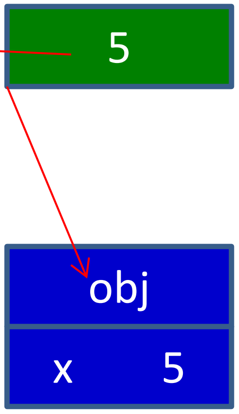
Numbers Classes- A Demo

- java.lang.Object
  - java.lang.Boolean
  - java.lang.Character
  - java.lang.Number
    - java.lang.Byte
    - java.lang.Double
    - java.lang.Float
    - java.lang.Integer
    - java.lang.Long
    - java.lang.Short

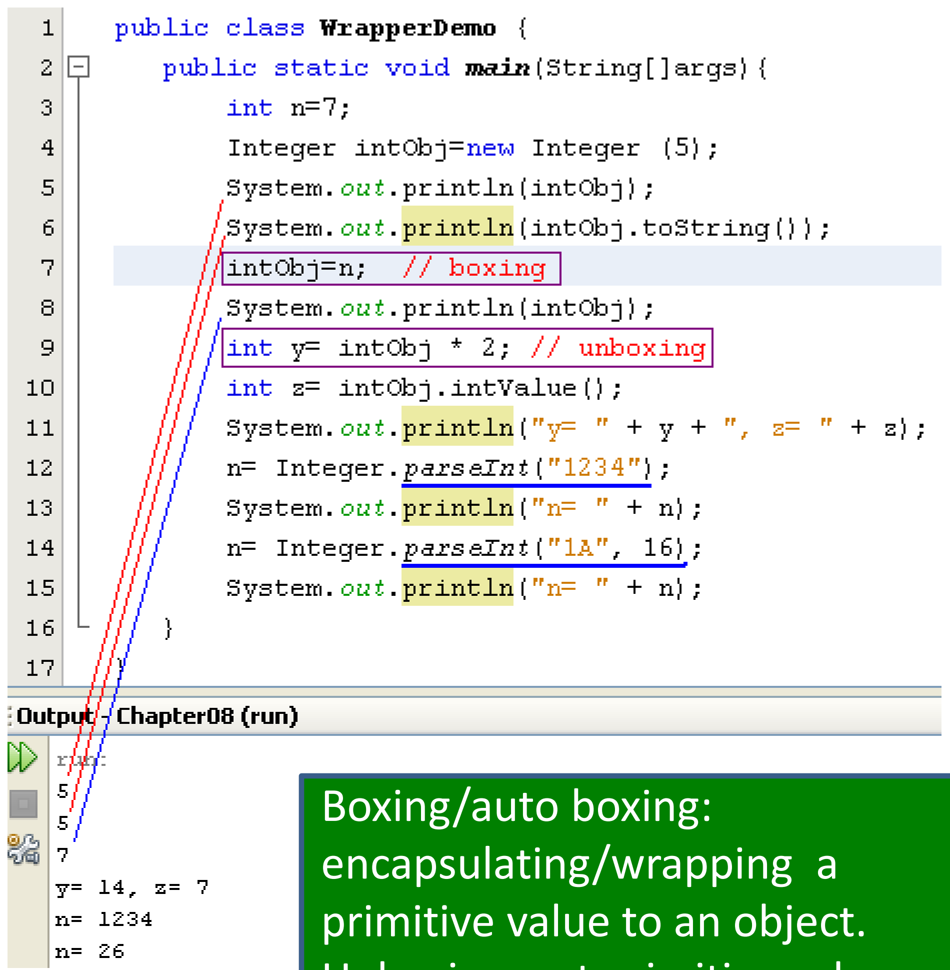


`int intValue()`

```
Integer(int value)
Integer(String s)
```



```
int x= 5;
Integer obj = new Integer(5);
Integer obj2 = new Integer ("123");
```



```java
public class WrapperDemo {
    public static void main(String[]args){
        int n=7;
        Integer intObj=new Integer (5);
        System.out.println(intObj);
        System.out.println(intObj.toString());
        intObj=n;  // boxing
        System.out.println(intObj);
        int y= intObj * 2; // unboxing
        int z= intObj.intValue();
        System.out.println("y= " + y + ", z= " + z);
        n= Integer.parseInt("1234");
        System.out.println("n= " + n);
        n= Integer.parseInt("1A", 16);
        System.out.println("n= " + n);
    }
}
```

Output - Chapter08 (run)

```
run:
5
5
7
y= 14, z= 7
n= 1234
n= 26
```

Boxing/auto boxing: encapsulating/wrapping a primitive value to an object.
Unboxing: get primitive value wrapped in a wrapper object.

The java.lang.Math class

- The Math class in the **java.lang** package provides methods and constants for doing more advanced mathematical computation, including:
  - **Constants and Basic Methods:** Math.E, Math.PI,..
  - Basic static methods: `ceil(double d)`, `floor(double d)`, `abs(int i)`…
  - **Exponential and Logarithmic Methods:** `exp(double d)`, `sqrt(double d)`, `pow(double base, double exponent)`
  - **Trigonometric Methods:** `cos(double d)`, `sin(double d)`
  - **Random Numbers:** The random() method returns a pseudo-randomly selected number between 0.0 and 1.0.

Auto boxing and Unboxing (1)

- Java 5.0 introduces two very simple but convenient functions that <u>unwrap wrapper</u> objects and <u>wrap up</u> primitives.
- Converting a primitive value into an object of the corresponding wrapper class is called auto boxing.
- Converting an object of a wrapper type to its corresponding primitive value is called unboxing.

Auto boxing and Unboxing…

- Sample of auto boxing and unboxing

```
Integer wrappedInt = 25; //boxing or auto boxing

Double area(double radius) {
    return Math.PI * radius * radius; //boxing
}

Integer wi = 234;
int times9 = wi * 9; //unboxing
```

Characters

- Unicode character, 2 bytes
- Character class also offers a number of useful class (i.e., static) methods for manipulating characters.
- Character ch = new Character('a');
- Some methods in this class
  - boolean isLetter(char ch)/ isDigit(char ch)/ isUpperCase(char ch)
  - char toUpperCase(char ch) …
- A character preceded by a backslash (\) is an *escape sequence* and has special meaning to the compiler.

Strings

- Java uses the **String**, **StringBuffer**, and **StringBuilder** classes to encapsulate strings of characters (16-bit Unicode).

```
java.lang.Object
    java.lang.String (implements java.lang.CharSequence,
                        java.lang.Comparable<T>, java.io.Serializable)
    java.lang.StringBuffer (implements java.lang.CharSequence,
                        java.io.Serializable)
    java.lang.StringBuilder (implements
                        java.lang.CharSequence, java.io.Serializable)
```

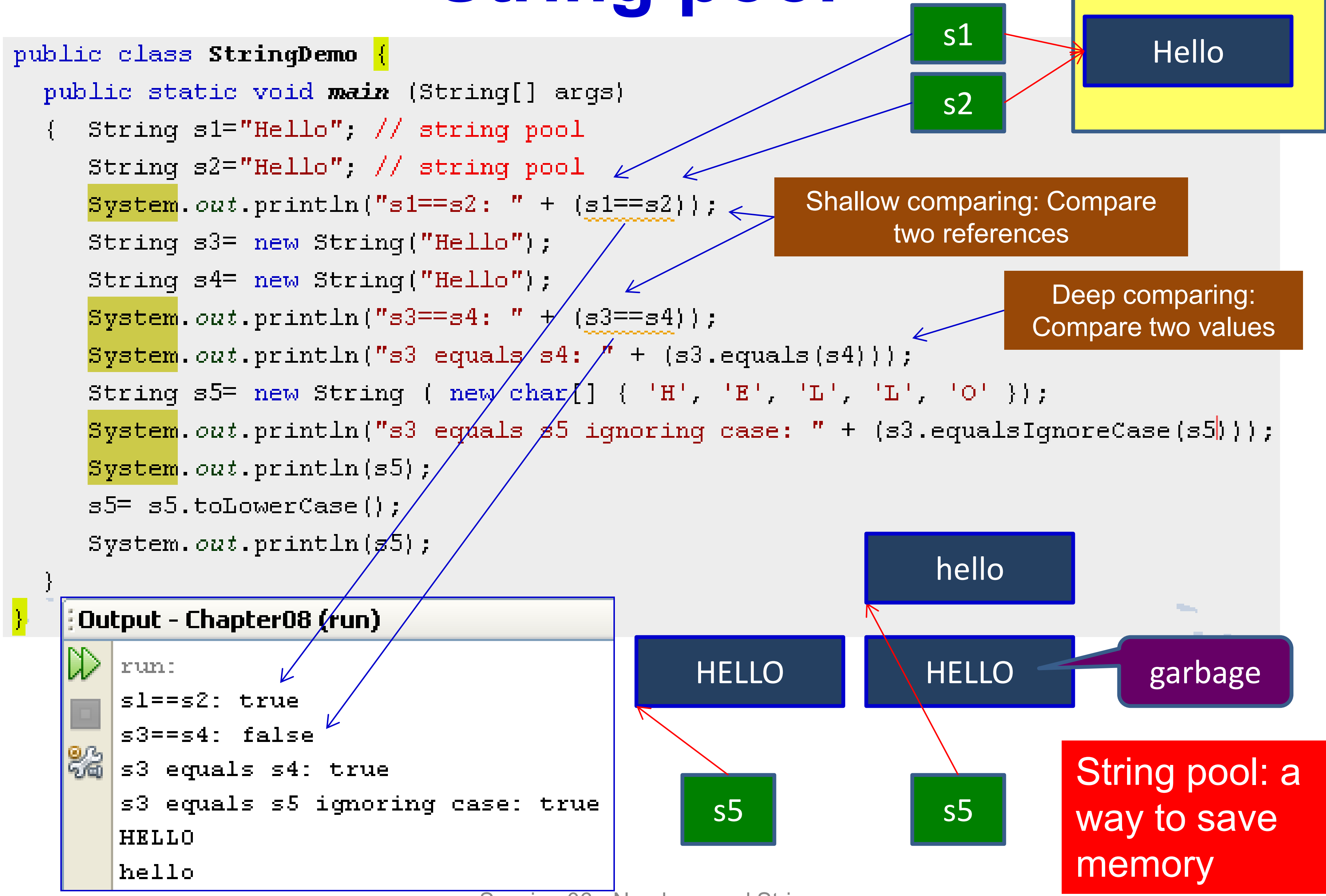
Interface **Serializable** declared methods for processing a string as a stream of characters (write string to file, …)

The *String* Class

- The String class contains an **immutable** string (Once an instance is created, the string it contains cannot be changed) ← **No setter is implemented**
- **Almost of it's methods will return a new string.**
- Construct a string:

```
String s1 = new String("immutable");
String s2=  new String (new char[] {'a', 'b', 'c'});
or
String s3 = "immutable";
```

String pool



```
public class StringDemo {
  public static void main (String[] args)
  {  String s1="Hello"; // string pool
     String s2="Hello"; // string pool
     System.out.println("s1==s2: " + (s1==s2));
     String s3= new String("Hello");
     String s4= new String("Hello");
     System.out.println("s3==s4: " + (s3==s4));
     System.out.println("s3 equals s4: " + (s3.equals(s4)));
     String s5= new String ( new char[] { 'H', 'E', 'L', 'L', 'O' });
     System.out.println("s3 equals s5 ignoring case: " + (s3.equalsIgnoreCase(s5)));
     System.out.println(s5);
     s5= s5.toLowerCase();
     System.out.println(s5);
  }
}
```

Output - Chapter08 (run)

```
run:
s1==s2: true
s3==s4: false
s3 equals s4: true
s3 equals s5 ignoring case: true
HELLO
hello
```

String pool
Hello
s1
s2
Shallow comparing: Compare two references
Deep comparing: Compare two values
hello
HELLO
HELLO
garbage
s5
s5

String pool: a way to save memory

The *String* Class

Compare 2 strings: should use equals()

```
String st1 = “abc”;
String st2 = “xyz”;
if(st1.equals(st2)){
    …
}
```

The *String* Class

Modifier and Type	Method and Description
char	charAt(int index)
char[]	toCharArray()
byte[]	getBytes()
int	codePointAt(int index), compareTo(String anotherString) compareToIgnoreCase(String str), hashCode(),indexOf(int ch), indexOf(…),lastIndexOf(…),length()
String	trim(),toString(),concat(String str), replace(…),replaceAll(…) replaceFirst(…),substring(…), toLowerCase(…),toUpperCase(…)
static String	copyValueOf(…), format(…), valueOf(…)
boolean	contains(CharSequence s), endsWith(String suffix), startsWith(…),isEmpty(),matches(String regex) equals(Object anObject), equalsIgnoreCase(…)
void	getChars(int srcBegin, int srcEnd, char[] dst, int dstBegin)
String[]	split(String regex), split(String regex, int limit)
CharSequence	subSequence(int beginIndex, int endIndex)

The *String* Class

```
run:
Enter original string:do not love me
Enter replaced string:love
Enter replacing string:hate
After replacing:do not hate me
Uppercase:DO NOT HATE ME
Origin:do not hate me
Enter the index of extracted character:3
The 3(th)character:n
```

```java
import java.util.Scanner;
public class StringDemo {
  public static void main(String aegs[]){
      Scanner sc= new Scanner(System.in);
      String origin, replaced, replacement;
      System.out.print("Enter original string:");
      origin= sc.nextLine();
      System.out.print("Enter replaced string:");
      replaced= sc.nextLine();
      System.out.print("Enter replacing string:");
      replacement= sc.nextLine();
      origin = origin.replaceAll(replaced, replacement);
      System.out.println("After replacing:" + origin);
      System.out.println("Uppercase:" + origin.toUpperCase());
      System.out.println("Origin:" + origin);
      System.out.print("Enter the index of extracted character:");
      int index= Integer.parseInt(sc.nextLine());
      System.out.format("The %d(th)character:%c\n", index, origin.charAt(index));
  }
}
```

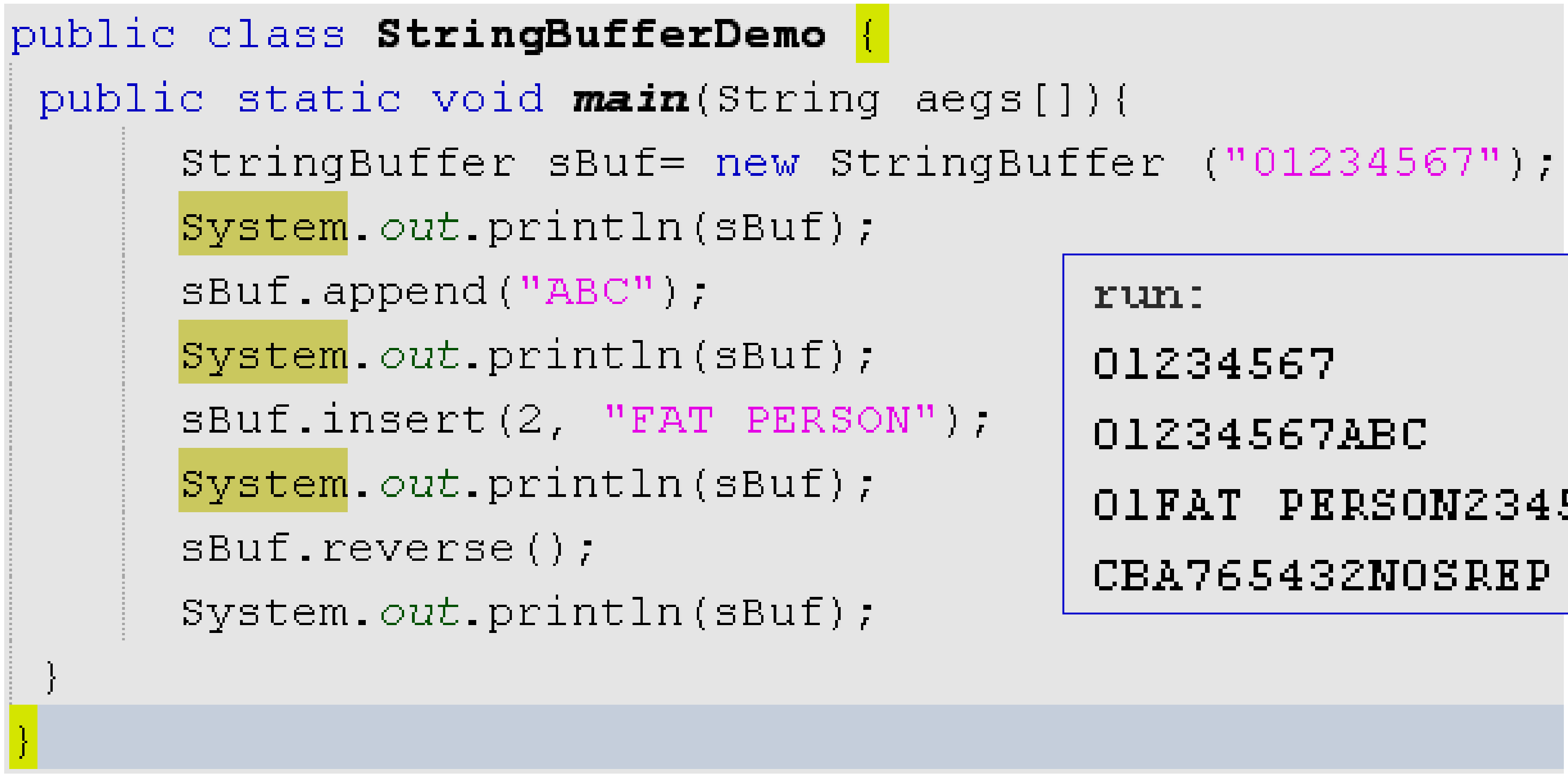
StringBuffer, StringBuilder Classes

- Java's **StringBuffer** and **StringBuilder** classes represent strings that can be dynamically modified.
  - StringBuffer is threadsafe.
  - StringBuilder (introduced in 5.0) is not threadsafe.
- Almost of their methods are the same as methods in the String class.

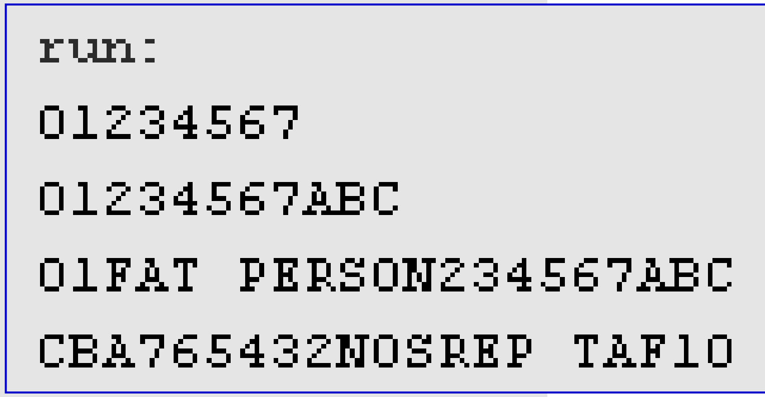
Thread: Unit of code (method) is running
Multi-threading program: A program has some threads running concurrently. If 2 threads access common data, their values are not un-predictable. So, in multi-thread programming, JVM supports a mechanism in which accesses to common resources must carry out in sequence based on synchronized methods.
Threadsafe class: A class with synchronized methods.

The *StringBuffer - threadsafe*

public final class **StringBuffer** extends Object
implements Serializable, CharSequence



```
public class StringBufferDemo {
 public static void main(String aegs[]){
     StringBuffer sBuf= new StringBuffer ("01234567");
     System.out.println(sBuf);
     sBuf.append("ABC");
     System.out.println(sBuf);
     sBuf.insert(2, "FAT PERSON");
     System.out.println(sBuf);
     sBuf.reverse();
     System.out.println(sBuf);
 }
}
```



```
run:
01234567
01234567ABC
01FAT PERSON234567ABC
CBA765432NOSREP TAF10
```

StringBuilder

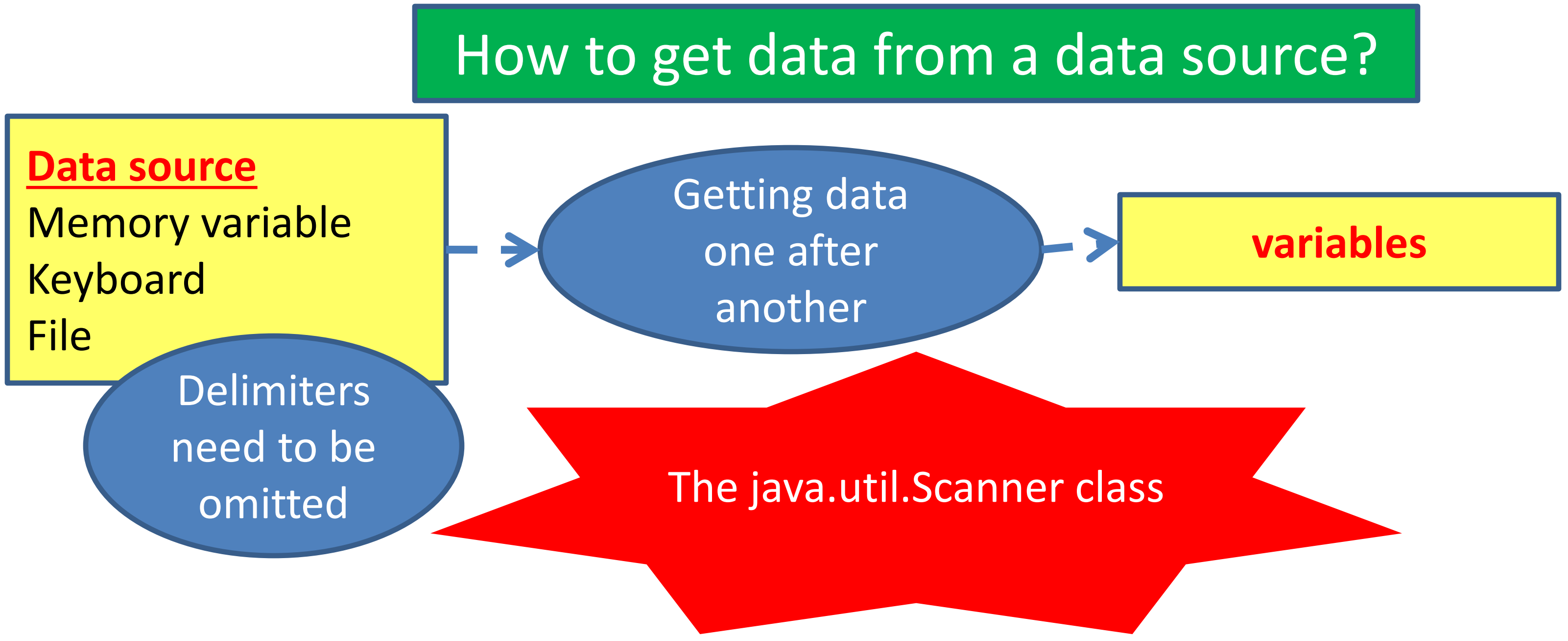
public final class **StringBuilder** extends Object
implements Serializable, CharSequence

- The StringBuilder class was introduced in 5.0. It is nearly identical to StringBuffer.
- Major difference: string builders are not threadsafe.
- If you want multiple threads to have concurrent access to a mutable string, use a string buffer.
- If your mutable string will be accessed only by a single thread, there is an advantage to using a string builder, which will generally execute faster than a string buffer.

String Concatenation, the Easy Way

- 02 ways:
  - String.concat() method of the String class and the StringBuffer.append().
  - Overloaded + operator.

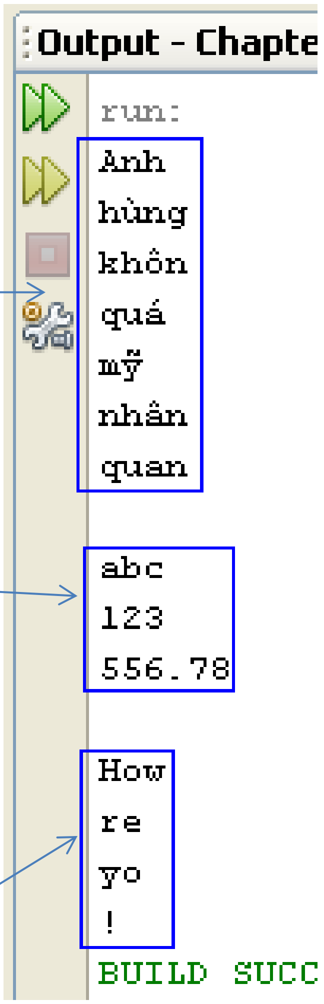
Scanning Text


How to get data from a data source?
Data source
Memory variable
Keyboard
File
Getting data one after another
variables
Delimiters need to be omitted
The java.util.Scanner class

- **Class: java.util.Scanner**
- **Data in data source are characters**
- **Methods for getting data: next(), nextXXX()**
- **Methods for checking availability of data : hasXXX()**
- **Token: group of characters that has a meaning.**

Scanning data from a string

```java
import java.util.Scanner;
public class ScannerDemo {
    public static void main(String[] args) {
      String S= "Anh hùng khôn quá mỹ nhân quan";
      Scanner sc1= new Scanner (S);
      while (sc1.hasNext()) System.out.println(sc1.next());
      System.out.println();
      String S2= "abc 123 556.78";
      Scanner sc2= new Scanner (S2);
      System.out.println(sc2.next());
      System.out.println(sc2.nextInt());
      System.out.println(sc2.nextDouble());
      System.out.println();
      String S3= "  How are     you!   ";
      String delim ="[au\\s]+"; // s:space, +: >=1 occurence
      Scanner sc3= new Scanner (S3);
      sc3.useDelimiter(delim);
      while (sc3.hasNext()) System.out.println(sc3.next());
    }
}
```

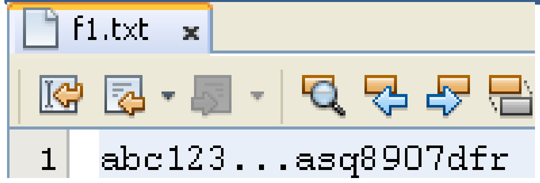

Output - Chapte

```
run:
Anh
hùng
khôn
quá
mỹ
nhân
quan

abc
123
556.78

How
re
yo
!
BUILD SUCC
```

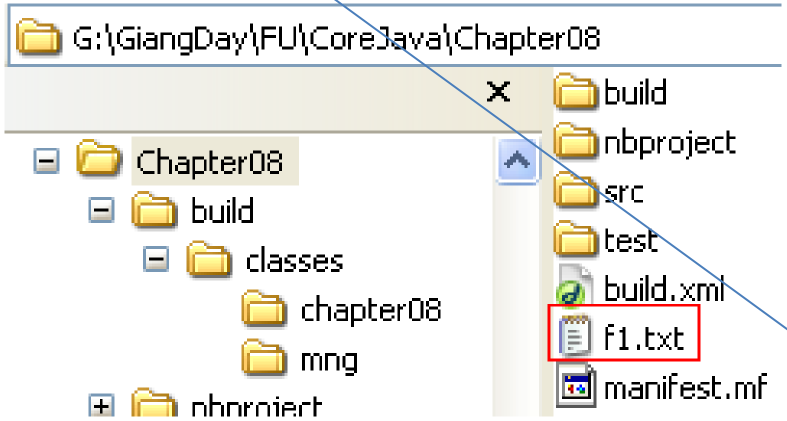
The default delimiter is the blank character. You can designate delimiters.
[au\\s] means that a, u and space(\s) are delimiters.
+ means that number of occurrences is equal or greater than 1

Scanning data from a text file Specifying Delimiters

Add New File/ Other/ Empty File
File name: f1.txt



```
f1.txt
1  abc123...asq8907dfr
```



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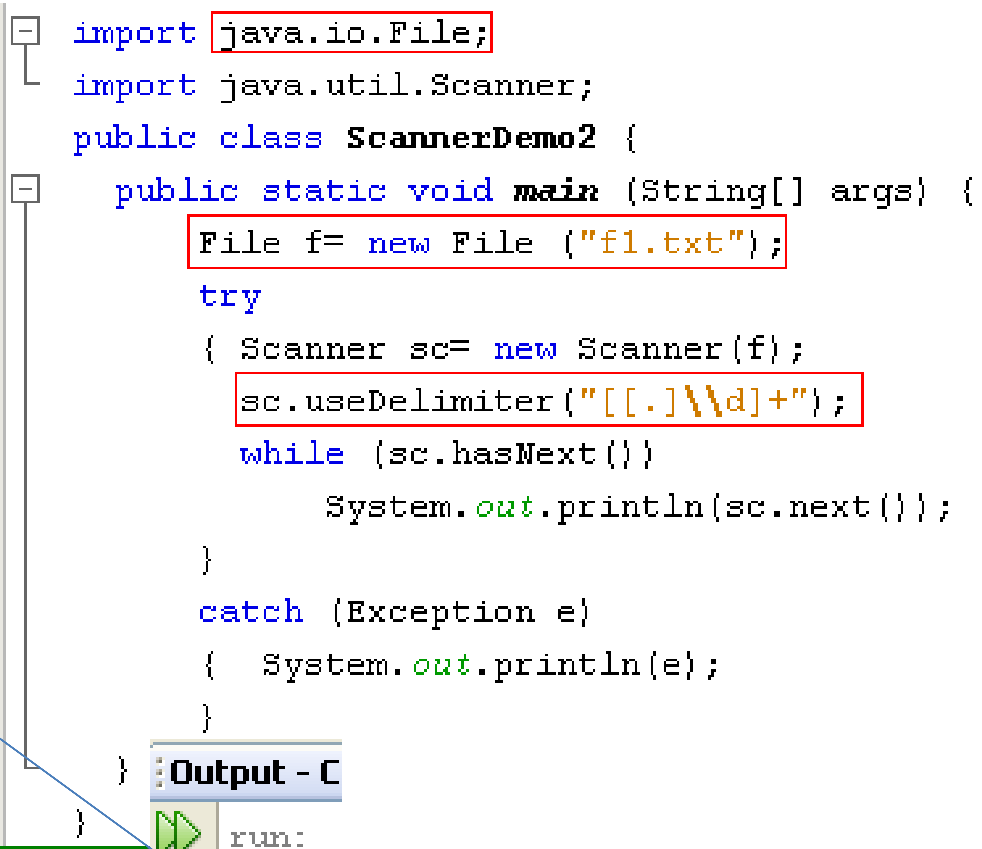
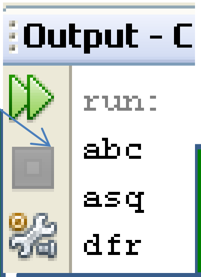


```java
import java.io.File;
import java.util.Scanner;
public class ScannerDemo2 {
   public static void main (String[] args) {
        File f= new File ("f1.txt");
        try
        { Scanner sc= new Scanner(f);
          sc.useDelimiter("[[.]\\d]+");
          while (sc.hasNext())
              System.out.println(sc.next());
        }
        catch (Exception e)
        {  System.out.println(e);
        }
   }
}
```



Output - C

```
run:
abc
asq
dfr
```

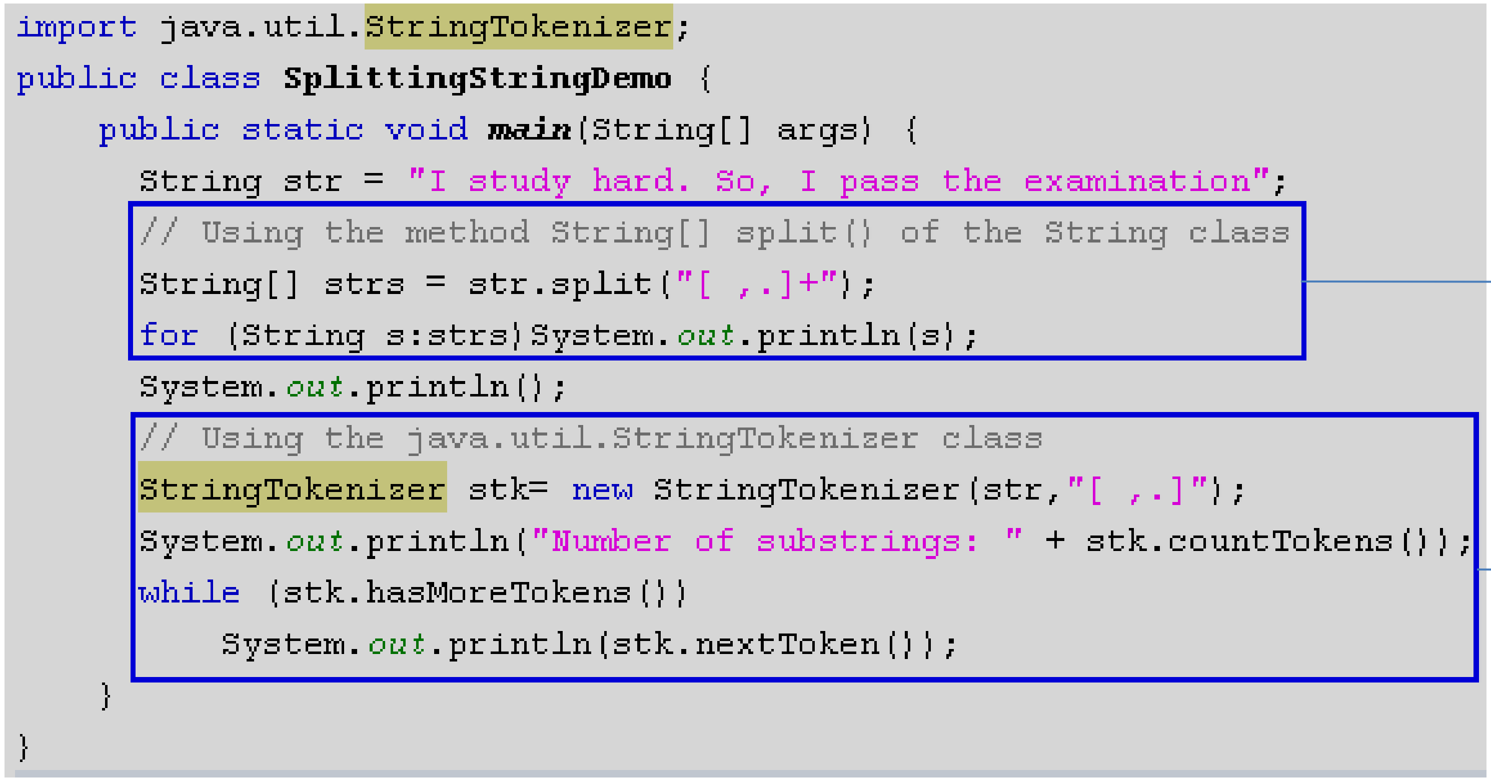
Common Patterns:
[ ] : representing a character
. (arbitrary character)
\d (digits) \w (word characters) \s (space)
Quantifiers: * (>=0) , + (>=1) , ? (zero or one)

[a-zA-Z] : a character from a to z or A to Z

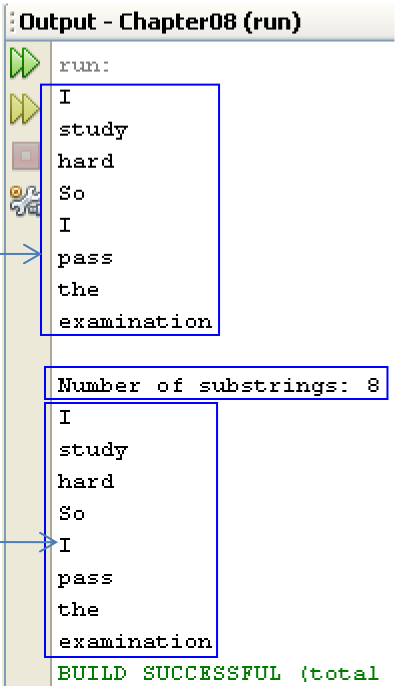
Read java documentation for more details
Class: java.util.regex.Pattern

Splitting a string into substrings

The method **split(delimiters) of the class String and the java.util.StringTokenizer are used.**



```java
import java.util.StringTokenizer;
public class SplittingStringDemo {
    public static void main(String[] args) {
      String str = "I study hard. So, I pass the examination";
      // Using the method String[] split() of the String class
      String[] strs = str.split("[ ,.]+");
      for (String s:strs)System.out.println(s);
      System.out.println();
      // Using the java.util.StringTokenizer class
      StringTokenizer stk= new StringTokenizer(str,"[ ,.]");
      System.out.println("Number of substrings: " + stk.countTokens());
      while (stk.hasMoreTokens())
          System.out.println(stk.nextToken());
    }
}
```



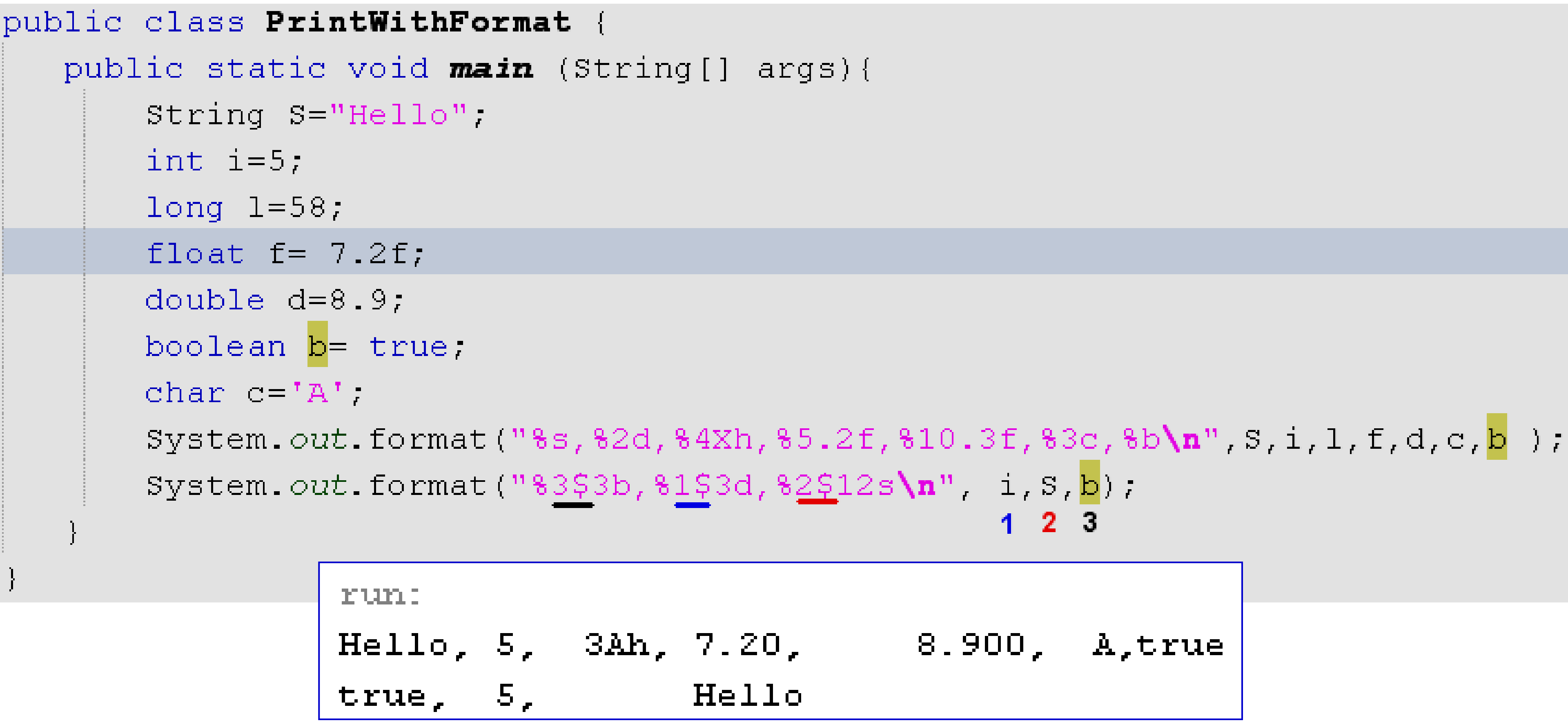
Output - Chapter08 (run)

```
run:
I
study
hard
So
I
pass
the
examination

Number of substrings: 8
I
study
hard
So
I
pass
the
examination
BUILD SUCCESSFUL (total
```

Formatting Output

%[argument_index$][flags][width][.precision]conversion
See API documentation for more details (api/java/util/Formatter.html#syntax).



```
public class PrintWithFormat {
   public static void main (String[] args){
       String S="Hello";
       int i=5;
       long l=58;
       float f= 7.2f;
       double d=8.9;
       boolean b= true;
       char c='A';
       System.out.format("%s,%2d,%4Xh,%5.2f,%10.3f,%3c,%b\n",S,i,l,f,d,c,b );
       System.out.format("%3$3b,%1$3d,%2$12s\n", i,S,b);
                                                 1 2 3
   }
}
```

```
run:
Hello, 5,  3Ah, 7.20,     8.900,  A,true
true,  5,       Hello
```

Formatting Output

```java
import java.text.DecimalFormat;
public class DecimalFormatDemo {
    static public String customFormat(String pattern, double value ){
        DecimalFormat myFormatter = new DecimalFormat(pattern);
        String output = myFormatter.format(value);
        return output;
    }
    static public void main(String[] args) {
        System.out.println(customFormat("###,###.###", 123456.789));
        System.out.println(customFormat("###.##", 123456.789));
        System.out.println(customFormat("000000.000", 123.78));
        System.out.println(customFormat("$###,###.###", 12345.67));
    }
}
```

```
run:
123,456.789
123456.79
000123.780
$12,345.67
```

Summary

- **Working with Numbers**:
  - Wrapper classes: Number, Character
  - The java.lang.Math class
  - Autoboxing and unboxing .
- **The java.lang.Math**
- **String class**:
  - Create and manipulate strings.
  - Compares the String and StringBuilder classes.
- **Scanning Text**
- **Formatting output**