Date	Chapter
11/6/2006	Chapter 10, start **Chapter 11**
11/13/2006	Chapter 11, start Chapter 12
11/20/2006	Chapter 12
11/27/2006	Chapter 13
12/4/2006	Final Exam
12/11/2006	Project Due

Input / Output Framework

Home

java.io Framework

A set of classes used for:
reading and writing from files
reading from console

Home

Streams of Bytes

- A Stream is a sequential sequence of bytes. It can be used as a source of Input or a destination of Output
  - We read information form an Input Stream
  - We write information into an Output Stream

Writer

Stream

Reader

Home

Streams of Bytes

- Standard I/O Streams in Java
  - System.in
    - Represent keyboard input, or disk
  - System.out
    - (represents a particular window in the OS
  - System.err
    - (represents a particular window in the OS

Writer

Stream

Reader

Home

Streams of Bytes

- The Java Class Library contains many classes for defining I/O streams with various characteristics
  - Files
  - Memory
  - Strings
  - Objects
  - Characters
  - Raw Bytes
  - Buffering

Home

System.out

- System is a class in java.lang package
- out is a a static constant field, which is an object of class PrintStream.
- PrintStream is a class in java.io package

- Since out is static we can refer to it using the class name

System.out

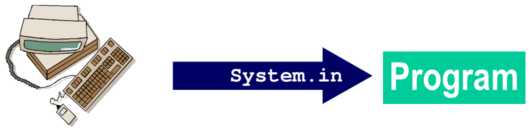
- PrintStream Class has 2 methods for printing, print and println that accept any argument type and print to the standard java console.

System.out.print("What's Up?");

Home

Input Streams: System.in

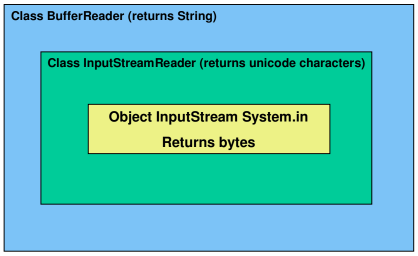
- System.in: the standard input stream
  - By default, reads characters from the keyboard



- Can use System.in many ways
  - Directly (low-level access)
  - Through layers of abstraction (high-level access)

Home

System.in Object



Class BufferReader (returns String)

Class InputStreamReader (returns unicode characters)

Object InputStream System.in

Returns bytes

BufferedReader inStream = new BufferedReader(new InputStreamReader(System.in));

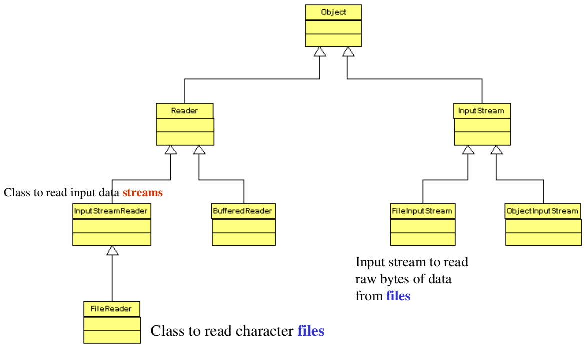
Home

Selected Input Classes in the *java.io* Package

Class	Description
`Reader`	*Abstract* superclass for input classes
`FileReader`	Class to read character **files**
`FileInputStream`	Input stream to read raw bytes of data from **files**
`InputStream`	*Abstract* superclass representing a stream of **raw bytes**
`InputStreamReader`	Class to read input data **streams of characters**
`BufferedReader`	Class providing more efficient reading of character files (**Strings**)
`ObjectInputStream`	Class to read/recover objects from a file written using *ObjectOutputStream*

Home

Hierarchy for Input Classes



Class to read input data **streams**

Input stream to read raw bytes of data from **files**

Class to read character **files**

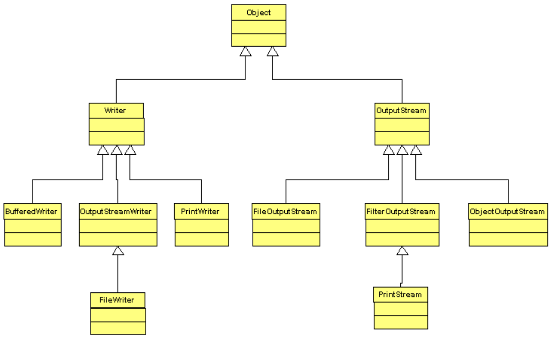
Home

Selected *java.io* Output Classes

Class	Description
`Writer`	*Abstract* superclass for output classes
`OutputStreamWriter`	Class to write output data streams
`OutputStream`	*Abstract* superclass representing an output stream of raw bytes
`FileWriter`	Class for writing to character files
`BufferedWriter`	More efficient writing to character files
`PrintWriter`	Prints basic data types, *Strings*, and objects
`PrintStream`	Supports printing various data types conveniently
`FileOutputStream`	Output stream for writing raw bytes of data to files
`ObjectOutputStream`	Class to write objects to a file

Home

Hierarchy for Output Classes



Home

Reading from the Java Console

- *System.in* is the default standard input device, which is tied to the Java Console.
- We have read from the console by associating a *Scanner* object with the standard input device:

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

- We can also read from the console using these subclasses of *Reader:*
  - *InputStreamReader*
  - *BufferedReader,* uses buffering (read-ahead) for efficient reading

Opening an InputStream

- When we construct an input stream or output stream object, the JVM associates the file name, standard input stream, or standard output stream with our object. This is **opening the file.**
- When we are finished with a file, we optionally call the *close* method to release the resources associated with the file.
- In contrast, the standard input stream (*System.in*), the standard output stream (*System.out*), and the standard error stream *(System.err*) are open when the program begins. They are intended to stay open and should not be closed.

Home

Software Engineering Tip

Calling the close method is optional. When the program finishes executing, all the resources of any unclosed files are released.

It is good practice to call the *close* method, especially if you will be opening a number of files (or opening the same file multiple times.)

Do not close the standard input, output, or error devices, however. They are intended to remain open.

Home

Console Input Class Constructors

Class	Constructor
`InputStreamReader`	`InputStreamReader( InputStream is )` constructs an *InputStreamReader* object from an *InputStream* object. For console input, the *InputStream* object is *System.in.*
`BufferedReader`	`BufferedReader( Reader r )` constructs a *BufferedReader* object from a *Reader* object – here the *Reader* object will be an *InputStreamReader* object.

Home

Methods of the *BufferedReader* Class

Return value	Method name and argument list
`String`	`readLine( )` reads a line of text from the current *InputStream* object, and returns the text as a *String*. Throws an *IOException*.
`void`	`close( )` releases resources associated with an open input stream. Throws an *IOException*.

- Because an *IOException* is a checked exception, we must call these methods within a *try* block.

Home

Console Input Example

```
import java.io.InputStreamReader; import java.io.BufferedReader;
import java.io.IOException;
public class ConsoleInput {
  public static void main( String [] args )   {
    String stringRead = "";
    try     {
      InputStreamReader isr = new InputStreamReader( System.in );
     BufferedReader br = new BufferedReader( isr );
     System.out.println( "Please enter a phrase or sentence > " );
      stringRead = br.readLine( );
    }
    catch( IOException ioe )
    {
      System.out.println( ioe.getMessage( ) );
    }
   System.out.println( "The string read was " + stringRead );
  }
}
```

Home

Alternative Coding

- This code:

```
InputStreamReader isr =
         new InputStreamReader( System.in );
BufferedReader br = new BufferedReader( isr );
```

can also be coded as one statement using an anonymous object:

```
BufferedReader br = new BufferedReader(
        new InputStreamReader( System.in ) );
```

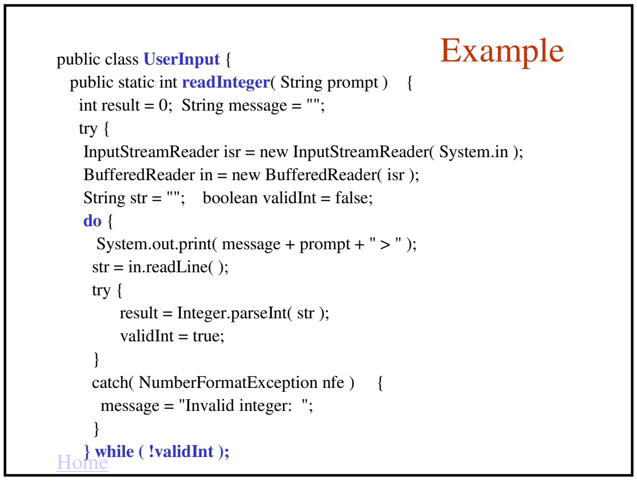
because the object reference *isr* is used only once.

Home

Hiding the Complexity

- We can hide the complexity by encapsulating *try* and *catch* blocks into a *UserInput* class, which is similar in concept to the *Scanner* class.
- We write our class so that the client program can retrieve user input with just one line of code.
- The *UserInput* class also validates that the user enters only the appropriate data type and reprompts the user if invalid data is entered.
- *See Examples next slide*

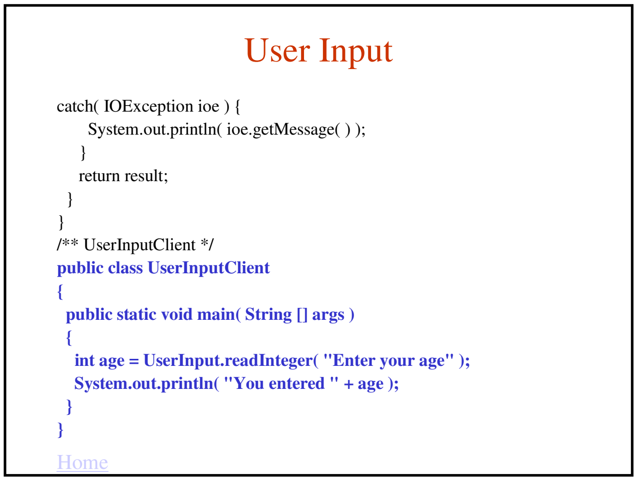
Home



Example

```
public class UserInput {
  public static int readInteger( String prompt )    {
    int result = 0;  String message = "";
    try {
     InputStreamReader isr = new InputStreamReader( System.in );
     BufferedReader in = new BufferedReader( isr );
     String str = "";    boolean validInt = false;
     do {
       System.out.print( message + prompt + " > " );
      str = in.readLine( );
      try {
           result = Integer.parseInt( str );
           validInt = true;
      }
      catch( NumberFormatException nfe )    {
        message = "Invalid integer:  ";
      }
     } while ( !validInt );
```

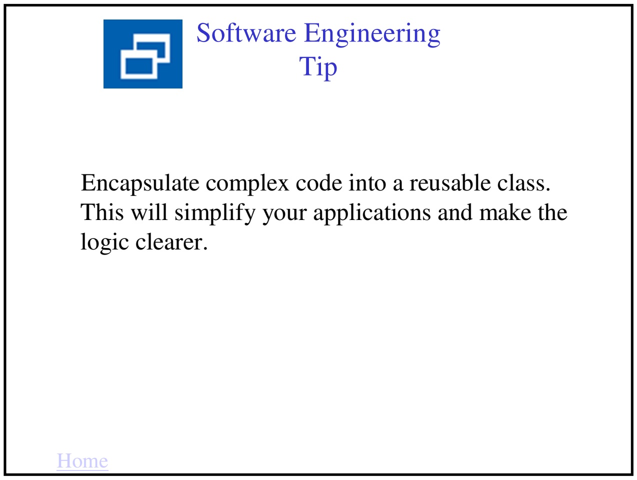
Home



User Input

```
catch( IOException ioe ) {
       System.out.println( ioe.getMessage( ) );
     }
     return result;
  }
}
/** UserInputClient */
public class UserInputClient
{
  public static void main( String [] args )
  {
    int age = UserInput.readInteger( "Enter your age" );
    System.out.println( "You entered " + age );
  }
}
```

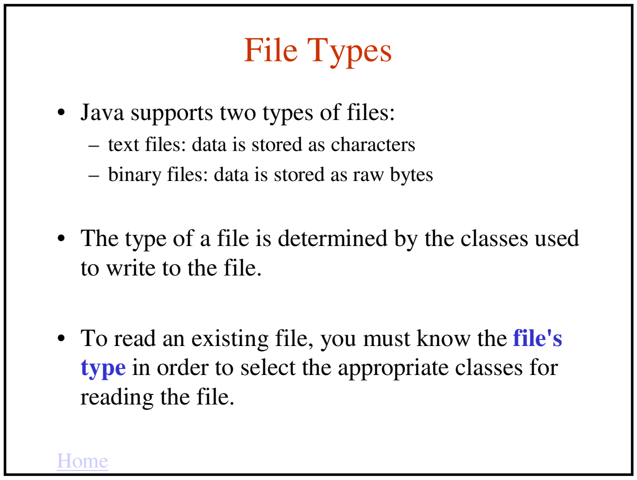
Home



Software Engineering Tip

Encapsulate complex code into a reusable class. This will simplify your applications and make the logic clearer.

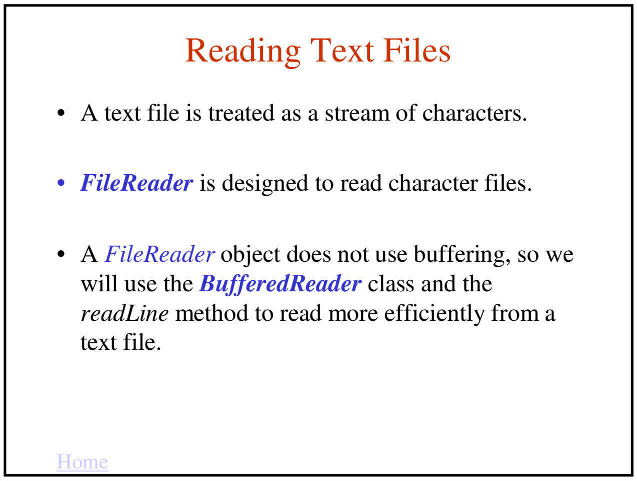
Home



File Types

- Java supports two types of files:
  - text files: data is stored as characters
  - binary files: data is stored as raw bytes
- The type of a file is determined by the classes used to write to the file.
- To read an existing file, you must know the **file's type** in order to select the appropriate classes for reading the file.

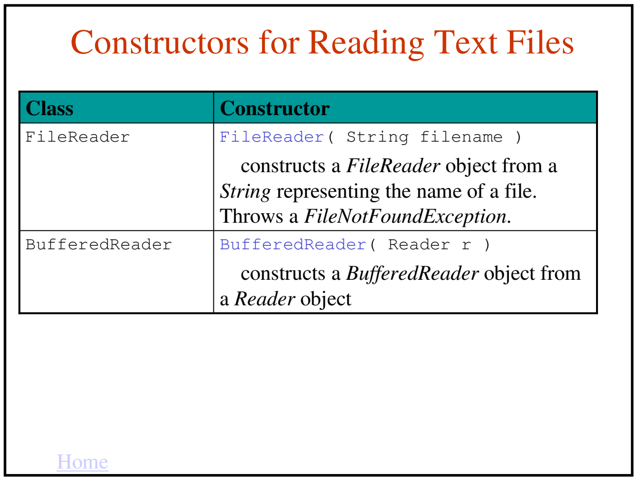
Home



Reading Text Files

- A text file is treated as a stream of characters.
- ***FileReader*** is designed to read character files.
- A *FileReader* object does not use buffering, so we will use the ***BufferedReader*** class and the *readLine* method to read more efficiently from a text file.

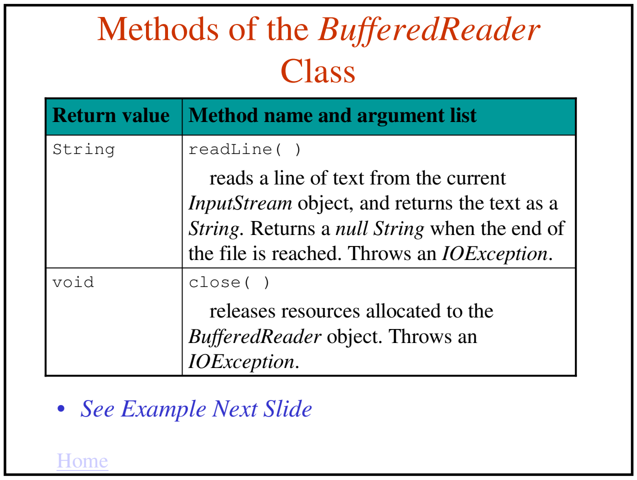
Home



Constructors for Reading Text Files

Class	Constructor
`FileReader`	`FileReader( String filename )` constructs a *FileReader* object from a *String* representing the name of a file. Throws a *FileNotFoundException*.
`BufferedReader`	`BufferedReader( Reader r )` constructs a *BufferedReader* object from a *Reader* object

Home

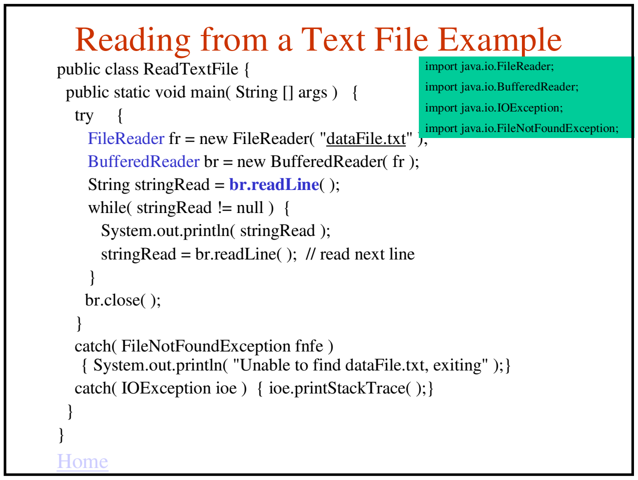


Methods of the *BufferedReader* Class

Return value	Method name and argument list
`String`	`readLine( )` reads a line of text from the current *InputStream* object, and returns the text as a *String*. Returns a *null String* when the end of the file is reached. Throws an *IOException*.
`void`	`close( )` releases resources allocated to the *BufferedReader* object. Throws an *IOException*.

- *See Example Next Slide*

Home



Reading from a Text File Example

```
import java.io.FileReader;
import java.io.BufferedReader;
import java.io.IOException;
import java.io.FileNotFoundException;
```

```
public class ReadTextFile {
  public static void main( String [] args )   {
    try     {
       FileReader fr = new FileReader( "dataFile.txt" );
       BufferedReader br = new BufferedReader( fr );
       String stringRead = br.readLine( );
       while( stringRead != null )  {
          System.out.println( stringRead );
          stringRead = br.readLine( );  // read next line
       }
      br.close( );
    }
    catch( FileNotFoundException fnfe )
     { System.out.println( "Unable to find dataFile.txt, exiting" );}
    catch( IOException ioe )  { ioe.printStackTrace( );}
  }
}
```

Home

Writing to Text Files

- Several situations can exist:
  - the file does not exist
  - the file exists and we want to replace the current contents
  - the file exists and we want to append to the current contents
- We specify whether we want to replace the contents or append to the current contents when we construct our *FileWriter* object.

Home

Constructors for Writing Text Files

Class	Constructor
`FileWriter`	`FileWriter( String filename, boolean mode )` constructs a *FileWriter* object from a *String* representing the name of a file. If the file does not exist, it is created. If *mode* is *false*, the current contents of the file, if any, will be replaced. If *mode* is *true*, writing will append data to the end of the file. Throws an *IOException*.
`BufferedWriter`	`BufferedWriter( Writer w )` constructs a *BufferedWriter* object from a *Writer* object

Home

Methods of the *BufferedWriter* Class

Return value	Method name and argument list
`void`	`write( String s )` writes a *String* to the current *OutputStream* object. This method is inherited from the *Writer* class. Throws an *IOException*.
`void`	`newLine( )` writes a line separator. Throws an *IOException*.
`void`	`close( )` releases resources allocated to the *BufferedWriter* object. Throws an *IOException*.

- *See Examples Next Slide*

Home

Writing to a file Example

```
import java.io.FileWriter;
import java.io.BufferedWriter;
import java.io.IOException;
```

```
public class WriteTextFile {
  public static void main( String [] args )   {
    try   {
       FileWriter fw = new FileWriter( "output.txt", false );
       BufferedWriter bw = new BufferedWriter( fw );
     bw.write( "I never saw a purple cow," );
       bw.newLine( );     bw.write( "I never hope to see one;" );
       bw.newLine( );     bw.write( "But I can tell you, anyhow," );
       bw.newLine( );     bw.write( "I'd rather see than be one!" );
       bw.newLine( );
      bw.close( );  System.out.println( "File written successfully" );
    }
    catch( IOException ioe )   {  ioe.printStackTrace( );  }
  }
}
```

Home

Reading Structured Text Files

- Some text files are organized into lines that represent a **record --** a set of data values containing information about an item.
- The data values are separated by one or more **delimiters;** that is, a special character or characters separate one value from the next.
- As we read the file, we need to **parse** each line; that is, separate the line into the individual data values called **tokens**.

Home

Example

- An airline company could store data in a file where each line represents a flight segment containing the following data:
  - flight number
  - origin airport
  - destination airport
  - number of passengers
  - average ticket price
- Such a file could contain the following data:

```
AA123,BWI,SFO,235,239.5
AA200,BOS,JFK,150,89.3
AA900,LAX,CHI,201,201.8
…
```

- In this case, the delimiter is a comma.

Home

The *StringTokenizer* Class

- The ***StringTokenizer*** class is designed to parse *Strings* into tokens.
- ***StringTokenizer*** is in the *java.util* package.
- When we construct a *StringTokenizer* object, we specify the delimiters that separate the data we want to tokenize. The default delimiters are the whitespace characters.

Home

Two *StringTokenizer* Constructors

Constructor name and argument list
`StringTokenizer( String str )` constructs a *StringTokenizer* object for the specified *String* using space, tab, carriage return, newline, and form feed as the default delimiters
`StringTokenizer( String str, String delim )` constructs a *StringTokenizer* object for the specified *String* using *delim* as the delimiters

Home

Useful *StringTokenizer* Methods

Return value	Method name and argument list
`int`	`countTokens( )` returns the number of unretrieved tokens in this object; the count is decremented as tokens are retrieved.
`String`	`nextToken( )` returns the next token
`boolean`	`hasMoreTokens( )` returns *true* if more tokens are available to be retrieved; returns *false*, otherwise.

Home

Using *StringTokenizer*

```
import java.util.StringTokenizer;
public class UsingStringTokenizer
{
  public static void main( String [] args )
  {
   String flightRecord1 = "AA123,BWI,SFO,235,239.5";
   StringTokenizer stfr1 =
       new StringTokenizer( flightRecord1, "," );
       // the delimiter is a comma

   while ( stfr1.hasMoreTokens( ) )
     System.out.println( stfr1.nextToken( ) );
  }
}
```

- *See Example 11.14 UsingStringTokenizer.java*

Home

Common Error Trap

Why didn't we use a *for* loop and the *countTokens* method?

```
for ( int i = 0; i < strfr1.countTokens( ); i++ )
    System.out.println( stfr1.nextToken( ) );
```

This code won't work because the return value of *countTokens* is the number of tokens **remaining to be retrieved.**

The body of the loop retrieves one token, so each time we evaluate the loop condition by calling the *countTokens* method, the return value is 1 fewer.

The result is that we retrieve only half of the tokens.

Home

Example Using *StringTokenizer*

- The file *flight.txt* contains the following comma-separated flight data on each line:
  `flight number, origin airport, destination airport, number of passengers, average ticket price`
- The *FlightRecord* class defines instance variables for each flight data value
- The *ReadFlights* class reads data from *flights.txt,* instantiates *FlightRecord* objects, and adds them to an *ArrayList*.
- *See Examples 11.15 & 11.16*

Home

Writing Primitive Types to Text Files

- *FileOutputStream*, a subclass of the *OutputStream* class, is designed to write a stream of bytes to a file.
- The *PrintWriter* class is designed for converting primitive data types to characters and writing them to a text file.
  - *print* method, writes data to the file without a newline
  - *println* method, writes data to the file, then adds a newline

Home

Constructors for Writing Structured Text Files

Class	Constructor
`FileOutputStream`	`FileOutputStream( String filename, boolean mode )` constructs a *FileOutputStream* object from a *String* representing the name of a file. If the file does not exist, it is created. If *mode* is *false*, the current contents of the file, if any, will be replaced. If *mode* is *true*, writing will append data to the end of the file. Throws a *FileNotFoundException*.
`PrintWriter`	`PrintWriter( OutputStream os )` constructs a *PrintWriter* object from an *OutputStream* object

Home

Useful *PrintWriter* Methods

Return value	Method name and argument list
`void`	`print( dataType argument )` writes a *String* representation of the argument to the file.
`void`	`println( dataType argument )` writes a *String* representation of the argument to the file followed by a newline.
`void`	`close( )` releases the resources associated with the *PrintWriter* object

- The argument can be any primitive data type (except *byte* or *short*), a *char* array, or an object.
- *See Example Next Slide*

Home

Writing Raw Data

```
public class WriteGradeFile {
  public static void main( String [] args )   {
    try    {
      FileOutputStream fos = new FileOutputStream ( "grade.txt", false );
      PrintWriter pw = new PrintWriter( fos );
       pw.print( "Grade: " );                    pw.println( 95 );
      pw.print( "Letter grade: " );       pw.println( 'A');
      pw.print( "Current GPA: " );       pw.println( 3.68 );
      pw.print( "Successful student: " );pw.println( true );
      pw.close( );
    }
    catch( FileNotFoundException fnfe )
      {  System.out.println( "Unable to find grade.txt" );  }
  }
}
```

Home

Reading and Writing Objects

- Java also supports writing objects to a file and reading them as objects.
- This is convenient for two reasons:
  - We can write these objects directly to a file without having to convert the objects to primitive data types or *Strings*.
  - We can read the objects directly from a file, without having to read *Strings* and convert these *Strings* to primitive data types in order to instantiate objects.
- To read objects from a file, the objects must have been written to that file as objects.

Home

Writing Objects to a File

- To write an object to a file, its class must implement the ***Serializable*** interface, which indicates that:
  - the object can be converted to a byte stream to be written to a file
  - that byte stream can be converted back into a copy of the object when read from the file.
- The *Serializable* interface has no methods to implement. All we need to do is:
  - *import* the *java.io.Serializable* interface
  - add ***implements Serializable*** to the class header

Home

The *ObjectOutputStream* Class

- The ***ObjectOutputStream*** class, coupled with the ***FileOutputStream*** class, provides the functionality to write objects to a file.
- The ***ObjectOutputStream*** class provides a convenient way to write objects to a file.
  - Its *writeObject* method takes one argument: the object to be written.

Home

Constructors for Writing Objects

Class	Constructor
`FileOutputStream`	`FileOutputStream( String filename, boolean mode )` creates a *FileOutputStream* object from a *String* representing the name of a file. If the file does not exist, it is created. If *mode* is *false*, the current contents of the file, if any, will be replaced. If *mode* is *true*, writing will append data to the end of the file. Throws a *FileNotFoundException*.
`ObjectOutputStream`	`ObjectOutputStream( OutputStream out )` creates an *ObjectOutputStream* that writes to the *OutputStream out*. Throws an *IOException*.

Home

The *writeObject* Method

Return value	Method name and argument list
`void`	`writeObject( Object o )` writes the object argument to a file. That object must be an instance of a class that implements the *Serializable* interface. Otherwise, a run-time exception will be generated. Throws an *IOException*.

- *See Examples Next Slides*

Writing Objects

```
import java.io.FileOutputStream;
import java.io.ObjectOutputStream;
import java.io.FileNotFoundException;
import java.io.IOException;
```

```
public class WritingObjects {
  public static void main( String [] args )  {
   FlightRecord2 fr1 = new FlightRecord2( "AA31", "BWI", "SFO", 200, 235.9 );
   FlightRecord2 fr2 = new FlightRecord2( "CO25", "LAX", "JFK", 225, 419.9 );
   FlightRecord2 fr3 = new FlightRecord2( "US57", "IAD", "DEN", 175, 179.5 );
   try  {
    FileOutputStream fos = new FileOutputStream ( "objects", false );
    ObjectOutputStream oos = new ObjectOutputStream( fos );
    oos.writeObject( fr1 );  oos.writeObject( fr2 );
    oos.writeObject( fr3 );  oos.close( );
   }
   catch( FileNotFoundException fnfe )
     { System.out.println( "Unable to write to objects" );}
   catch( IOException ioe ) { ioe.printStackTrace( ); }
  }
}
```

Home

Omitting Data from the File

- The *writeObject* method does not write any object fields declared to be *static* or ***transient.***
- You can declare a field as *transient* if you can easily reproduce its value or if its value is 0.
  - Syntax to declare a field as *transient*:

```
accessModifier transient dataType fieldName
```

  - Example:

```
private transient double totalRevenue;
```

Home

Software Engineering Tip

To save disk space when writing to an object file, declare the class's fields as *static* or *transient,* where appropriate.

Reading Objects from a File

- The *ObjectInputStream* class, coupled with *FileInputStream*, provides the functionality to read objects from a file.
- The *readObject* method of the *ObjectInputStream* class is designed to read objects from a file.
- Because the *readObject* method returns a generic *Object*, we must type cast the returned object to the appropriate class.
- When the end of the file is reached, the *readObject* method throws an *EOFException*, so we detect the end of the file when we catch that exception.

Home

Constructors for Reading Objects

Class	Constructor
`FileInputStream`	`FileInputStream( String filename )` constructs a *FileInputStream* object from a *String* representing the name of a file. Throws a *FileNotFoundException*.
`ObjectInputStream`	`ObjectInputStream( InputStream in )` creates an *ObjectInputStream* from the *InputStream in*. Throws an *IOException*.

Home

The *readObject* Method

Return value	Method name and argument list
`Object`	`readObject( )` reads the next object and returns it. The object must be an instance of a class that implements the *Serializable* interface. When the end of the file is reached, an *EOFException* is thrown. Also throws an *IOException* and *ClassNotFoundException*

- *See Example 11.21 ReadingObjects.java*
  - Note that we use a *finally* block to close the file.

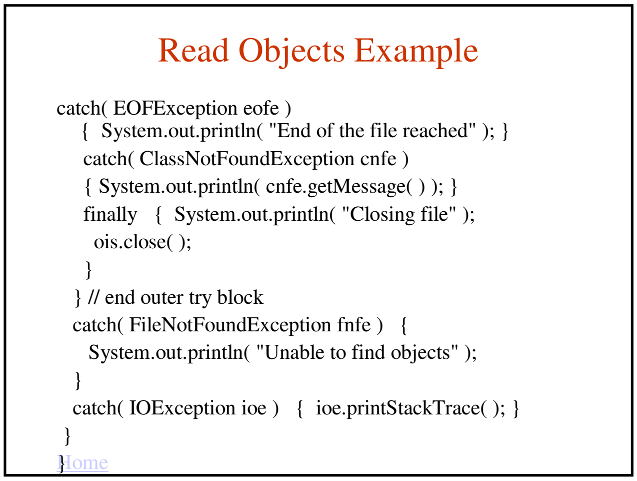
Home

Read Objects Example

```
public class ReadingObjects {
  public static void main( String [] args )   {
   try    {
     FileInputStream fis = new FileInputStream( "objects " );
     ObjectInputStream ois = new ObjectInputStream( fis );
     try  {
       while ( true )        {
    FlightRecord2 temp = ( FlightRecord2 ) ois.readObject( );
    System.out.println( temp );
       }
     } // end inner try block
```

```
import java.io.FileInputStream;
import java.io.ObjectInputStream;
import java.io.FileNotFoundException;
import java.io.EOFException;
import java.io.IOException;
```

Home



Read Objects Example

```
catch( EOFException eofe )
    {  System.out.println( "End of the file reached" ); }
    catch( ClassNotFoundException cnfe )
    { System.out.println( cnfe.getMessage( ) ); }
    finally   {  System.out.println( "Closing file" );
      ois.close( );
    }
  } // end outer try block
  catch( FileNotFoundException fnfe )   {
     System.out.println( "Unable to find objects" );
  }
  catch( IOException ioe )   {  ioe.printStackTrace( ); }
 }
}Home
```