LECTURE 09: WORKING WITH FILES

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PLAN

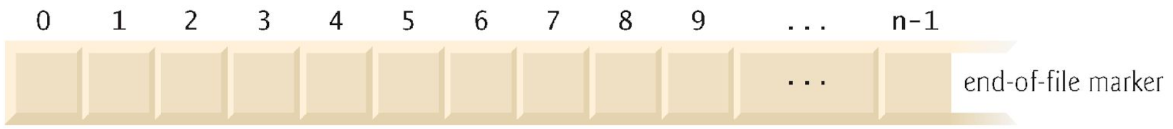
- File & Stream
- Binary Files
- Text Files
- Serialization

Introduction

- Data stored in variables and arrays is temporary
  - It’s lost when a local variable goes out of scope or when the program terminates
- For long-term retention of data, computers use files.
- Computers store files on secondary storage devices
  - hard disks, optical disks, flash drives and magnetic tapes.
- Data maintained in files is persistent data because it exists beyond the duration of program execution.

Files and Streams

- Java views each file as a sequential stream of bytes
- Every operating system provides a mechanism to determine the end of a file, such as an end-of-file marker or a count of the total bytes in the file that is recorded in a system-maintained administrative data structure.
- A Java program simply receives an indication from the operating system when it reaches the end of the stream



Files and Streams (cont.)

- File streams can be used to input and output data as bytes or characters.
- Streams that input and output bytes are known as byte-based streams, representing data in its binary format.
- Streams that input and output characters are known as character-based streams, representing data as a sequence of characters.
- Files that are created using byte-based streams are referred to as binary files.
- Files created using character-based streams are referred to as text files. Text files can be read by text editors.
- Binary files are read by programs that understand the specific content of the file and the ordering of that content.

Files and Streams (cont.)

- A Java program opens a file by creating an object and associating a stream of bytes or characters with it.
  - Can also associate streams with different devices.
- Java creates three stream objects when a program begins executing
  - System.in (the standard input stream object) normally inputs bytes from the keyboard
  - System.out (the standard output stream object) normally outputs character data to the screen
  - System.err (the standard error stream object) normally outputs character-based error messages to the screen.
- Class System provides methods setIn, setOut and setErr to redirect the standard input, output and error streams, respectively.

Files and Streams (cont.)

- Java programs perform file processing by using classes from package java.io.
- Includes definitions for stream classes
  - FileInputStream (for byte-based input from a file)
  - FileOutputStream (for byte-based output to a file)
  - FileReader (for character-based input from a file)
  - FileWriter (for character-based output to a file)
- You open a file by creating an object of one these stream classes. The object’s constructor opens the file.

Files and Streams (cont.)

- Can perform input and output of objects or variables of primitive data types without having to worry about the details of converting such values to byte format.
- To perform such input and output, objects of classes ObjectInputStream and ObjectOutputStream can be used together with the byte-based file stream classes FileInputStream and FileOutputStream.
- The complete hierarchy of classes in package java.io can be viewed in the online documentation at
- http://download.oracle.com/javase/6/docs/api/java/io/package-tree.html

Files and Streams (cont.)

- Class File provides information about files and directories.
- Character-based input and output can be performed with classes Scanner and Formatter.
  - Class Scanner is used extensively to input data from the keyboard. This class can also read data from a file.
  - Class Formatter enables formatted data to be output to any text-based stream in a manner similar to method System.out.printf.

Class File

- Class File provides four constructors.
- The one with a String argument specifies the name of a file or directory to associate with the File object.
  - The name can contain path information as well as a file or directory name.
  - A file or directory’s path specifies its location on disk.
  - An absolute path contains all the directories, starting with the root directory, that lead to a specific file or directory.
  - A relative path normally starts from the directory in which the application began executing and is therefore “relative” to the current directory.

Class File (cont.)

- The constructor with two String arguments specifies an absolute or relative path and the file or directory to associate with the File object.
- The constructor with File and String arguments uses an existing File object that specifies the parent directory of the file or directory specified by the String argument.
- The fourth constructor uses a URI object to locate the file.
  - A Uniform Resource Identifier (URI) is a more general form of the Uniform Resource Locators (URLs) that are used to locate websites.
- Figure 17.2 lists some common File methods. The
- http://download.oracle.com/javase/6/docs/api/java/io/File.html

Low-Level File I/O

- To read data from or write data to a file, we must create one of the Java stream objects and attach it to the file.
- A stream is a sequence of data items, usually 8-bit bytes.
- Java has two types of streams: an input stream and an output stream.
- An input stream has a source form which the data items come, and an output stream has a destination to which the data items are going.

Streams for Low-Level File I/O

- FileOutputStream and FileInputStream are two stream objects that facilitate file access.
- FileOutputStream allows us to output a sequence of bytes; values of data type byte.
- FileInputStream allows us to read in an array of bytes.

Sample: Low-Level File Output

```
//set up file and stream
File  outFile   = new File("sample1.data");

FileOutputStream
      outStream = new FileOutputStream( outFile );

//data to save
byte[] byteArray = {10, 20, 30, 40,
            50, 60, 70, 80};

//write data to the stream
outStream.write( byteArray );

//output done, so close the stream
outStream.close();
```

Sample: Low-Level File Input

```
//set up file and stream
File        inFile   = new File("sample1.data");
FileInputStream inStream = new FileInputStream(inFile);

//set up an array to read data in
int    fileSize  = (int)inFile.length();
byte[] byteArray = new byte[fileSize];

//read data in and display them
inStream.read(byteArray);
for (int i = 0; i < fileSize; i++) {
    System.out.println(byteArray[i]);
}

//input done, so close the stream
inStream.close();
```

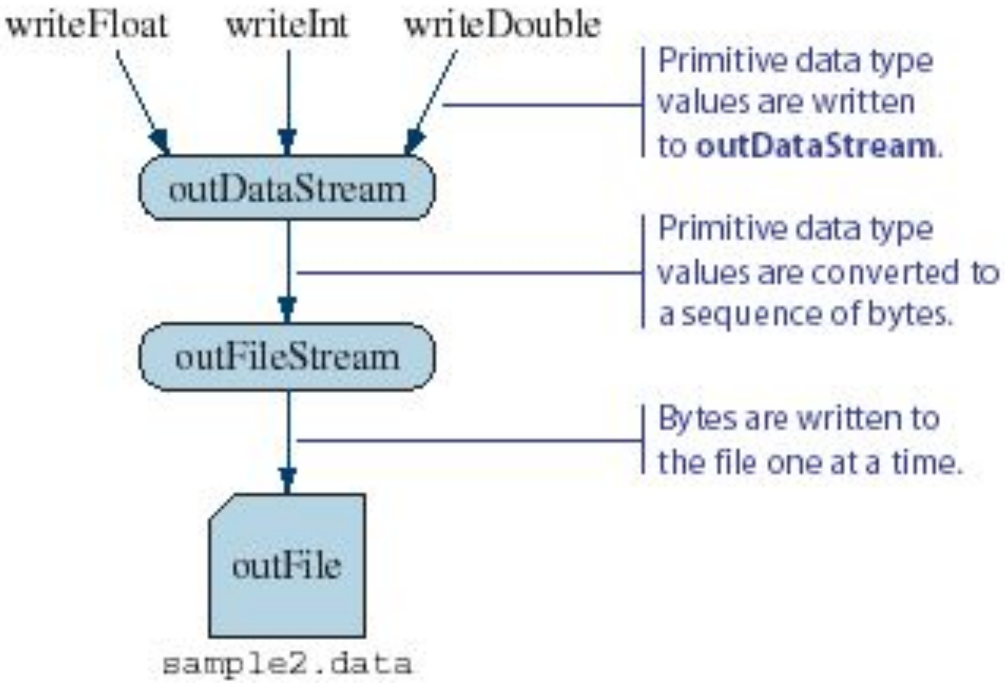
Streams for High-Level File I/O

- FileOutputStream and DataOutputStream are used to output primitive data values
- FileInputStream and DataInputStream are used to input primitive data values
- To read the data back correctly, we must know the order of the data stored and their data types

Setting up DataOutputStream

- A star

```
File             outFile       = new File( "sample2.data" );
FileOutputStream outFileStream = new FileOutputStream(outFile);
DataOutputStream outDataStream = new DataOutputSteam(outFileStream);
```



Primitive data type values are written to **outDataStream**.

Primitive data type values are converted to a sequence of bytes.

Bytes are written to the file one at a time.

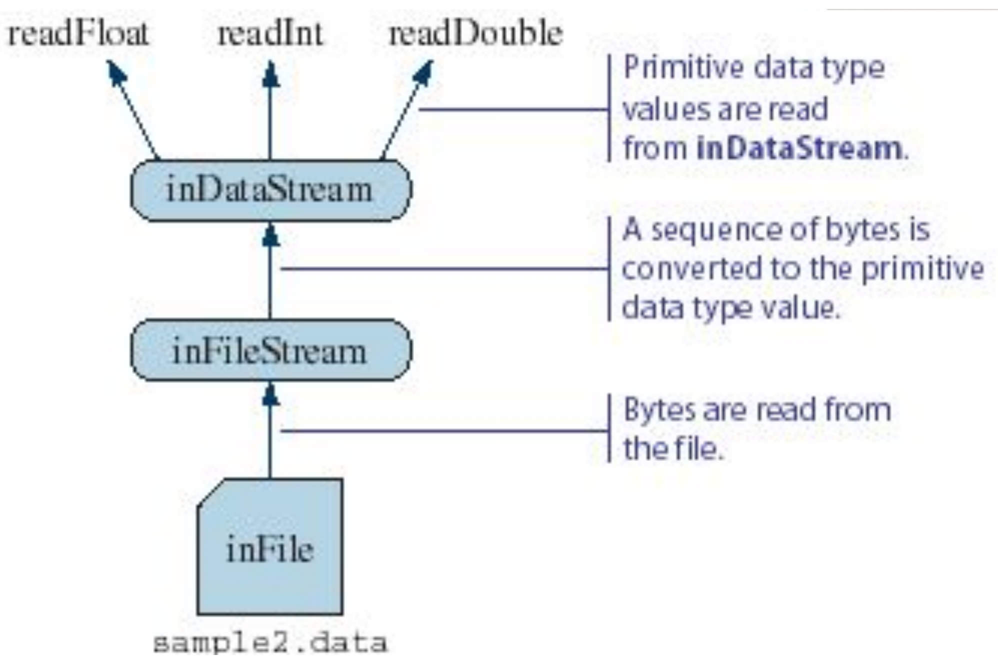
Sample Output

```
import java.io.*;
class Ch12TestDataOutputStream {
    public static void main (String[] args) throws IOException {

    . . . //set up outDataStream

    //write values of primitive data types to the stream
    outDataStream.writeInt(987654321);
    outDataStream.writeLong(11111111L);
    outDataStream.writeFloat(22222222F);
    outDataStream.writeDouble(3333333D);
    outDataStream.writeChar('A');
    outDataStream.writeBoolean(true);

    //output done, so close the stream
    outDataStream.close();
    }
}
```

Setting up DataInputStream

- A star

```
File             inFile         = new File( "sample2.data" );
FileInputStream  inFileStream   = new FileInputStream(inFile);
DataInputStream  inDataStream   = new DataInputSteam(inFileStream);
```



Primitive data type values are read from **inDataStream**.

A sequence of bytes is converted to the primitive data type value.

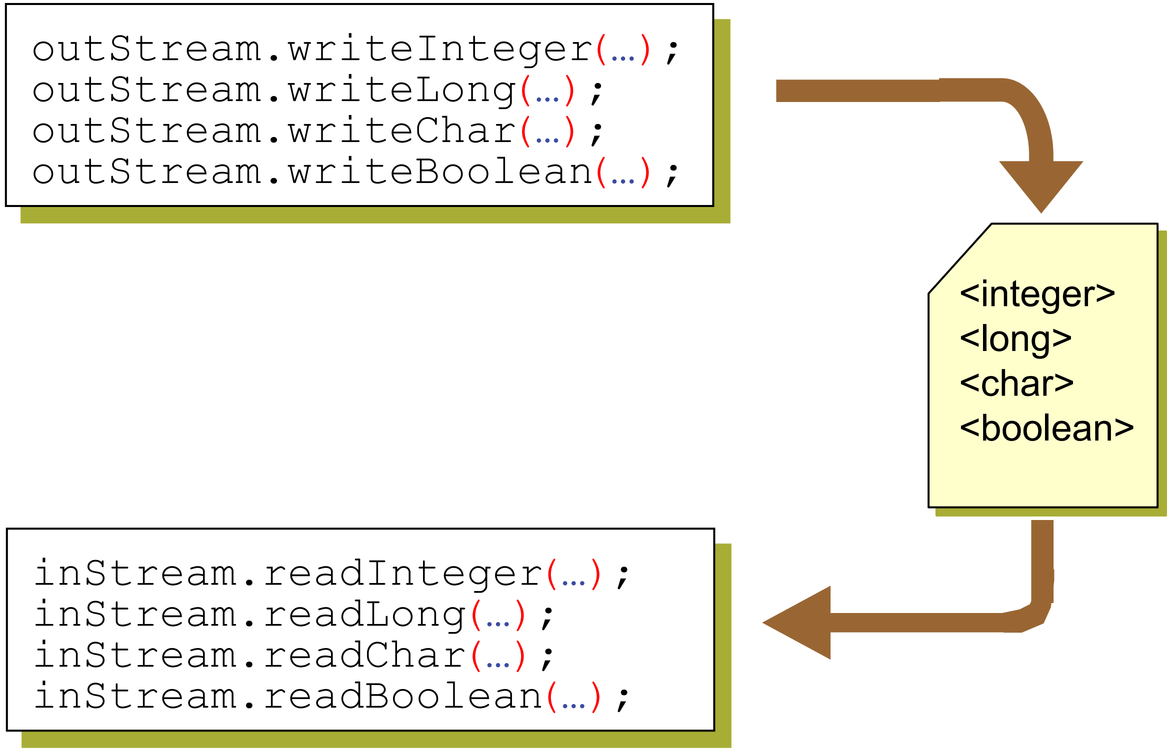
Bytes are read from the file.

Sample Input

```
import java.io.*;
class Ch12TestDataInputStream {
    public static void main (String[] args) throws IOException {

        . . . //set up inDataStream

        //read values back from the stream and display them
        System.out.println(inDataStream.readInt());
        System.out.println(inDataStream.readLong());
        System.out.println(inDataStream.readFloat());
        System.out.println(inDataStream.readDouble());
        System.out.println(inDataStream.readChar());
        System.out.println(inDataStream.readBoolean());

        //input done, so close the stream
        inDataStream.close();
    }
}
```

Reading Data Back in Right Order

- The order of write and read operations must match in order to read the stored primitive data back correctly.



```
outStream.writeInteger(…);
outStream.writeLong(…);
outStream.writeChar(…);
outStream.writeBoolean(…);
```

<integer>
<long>
<char>
<boolean>

```
inStream.readInteger(…);
inStream.readLong(…);
inStream.readChar(…);
inStream.readBoolean(…);
```

Text File Input and Output

- Instead of storing primitive data values as binary data in a file, we can convert and store them as a string data.
  - This allows us to view the file content using any text editor
- To output data as a string to file, we use a PrintWriter object
- To input data from a textfile, we use FileReader and BufferedReader classes
  - From Java 5.0 (SDK 1.5), we can also use the Scanner class for inputting textfiles

Sample Text File Output

```
import java.io.*;
class Ch12TestPrintWriter {
    public static void main (String[] args) throws IOException {

    //set up file and stream
    File outFile = new File("sample3.data");
    FileOutputStream outFileStream
            = new FileOutputStream(outFile);
    PrintWriter outStream = new PrintWriter(outFileStream);

    //write values of primitive data types to the stream
    outStream.println(987654321);
    outStream.println("Hello, world.");
    outStream.println(true);

    //output done, so close the stream
    outStream.close();
   }
}
```

Sample Text File Input

```
import java.io.*;
class Ch12TestBufferedReader {

    public static void main (String[] args) throws IOException {

    //set up file and stream
    File inFile = new File("sample3.data");
    FileReader fileReader = new FileReader(inFile);
    BufferedReader bufReader = new BufferedReader(fileReader);
    String str;

    str = bufReader.readLine();
    int i = Integer.parseInt(str);

    //similar process for other data types

    bufReader.close();
     }
}
```

Sample Text File Input with Scanner

```
import java.io.*;

class Ch12TestScanner {

    public static void main (String[] args) throws IOException {

    //open the Scanner
    Scanner scanner = new Scanner(new File("sample3.data"));

    //get integer
    int i = scanner.nextInt();

    //similar process for other data types

    scanner.close();
     }
}
```

Object Serialization

- To read an entire object from or write an entire object to a file, Java provides object serialization.
- A serialized object is represented as a sequence of bytes that includes the object’s data and its type information.
- After a serialized object has been written into a file, it can be read from the file and deserialized to recreate the object in memory.

Object Serialization (cont.)

- Classes ObjectInputStream and ObjectOutputStream, which respectively implement the ObjectInput and ObjectOutput interfaces, enable entire objects to be read from or written to a stream.
- To use serialization with files, initialize ObjectInputStream and ObjectOutputStream objects with FileInputStream and FileOutputStream objects.

Object Serialization (cont.)

- ObjectOutput interface method writeObject takes an Object as an argument and writes its information to an OutputStream.
- A class that implements ObjectOuput (such as ObjectOutputStream) declares this method and ensures that the object being output implements Serializable.
- ObjectInput interface method readObject reads and returns a reference to an Object from an InputStream.
  - After an object has been read, its reference can be cast to the object’s actual type.

Object Serialization (cont.)

- Objects of classes that implement interface Serializable can be serialized and deserialized with ObjectOutputStreams and ObjectInputStreams.
- Interface Serializable is a tagging interface.
  - It does not contain methods.
- A class that implements Serializable is tagged as being a Serializable object.
- An ObjectOutputStream will not output an object unless it is a Serializable object.

Saving Objects

```
File                      outFile
                              = new File("objects.data");
FileOutputStream   outFileStream
                              = new FileOutputStream(outFile);
ObjectOutputStream outObjectStream
                              = new
ObjectOutputStream(outFileStream);
```

```
Person person = new Person("Mr. Espresso", 20, 'M');

outObjectStream.writeObject( person );
```

```
account1        = new Account();
bank1             = new Bank();

outObjectStream.writeObject( account1 );
outObjectStream.writeObject( bank1    );
```

Could save objects from the different classes.

Reading Objects

```
File                      inFile
                               = new File("objects.data");
FileInputStream    inFileStream
                               = new FileInputStream(inFile);
ObjectInputStream inObjectStream
                               = new
ObjectInputStream(inFileStream);
```

```
Person person

      = (Person) inObjectStream.readObject( );
```

Must type cast to the correct object type.

```
Account account1
       = (Account) inObjectStream.readObject( );
Bank    bank1
          = (Bank) inObjectStream.readObject( );
```

Must read in the correct order.

Saving and Loading Arrays

- Instead of processing array elements individually, it is possible to save and load the whole array at once.

```
Person[] people = new Person[ N ];
                   //assume N already has a value

//build the people array
. . .
//save the array
outObjectStream.writeObject ( people );
```

```
//read the array

Person[ ] people = (Person[]) inObjectStream.readObject( );
```

Model View Controller

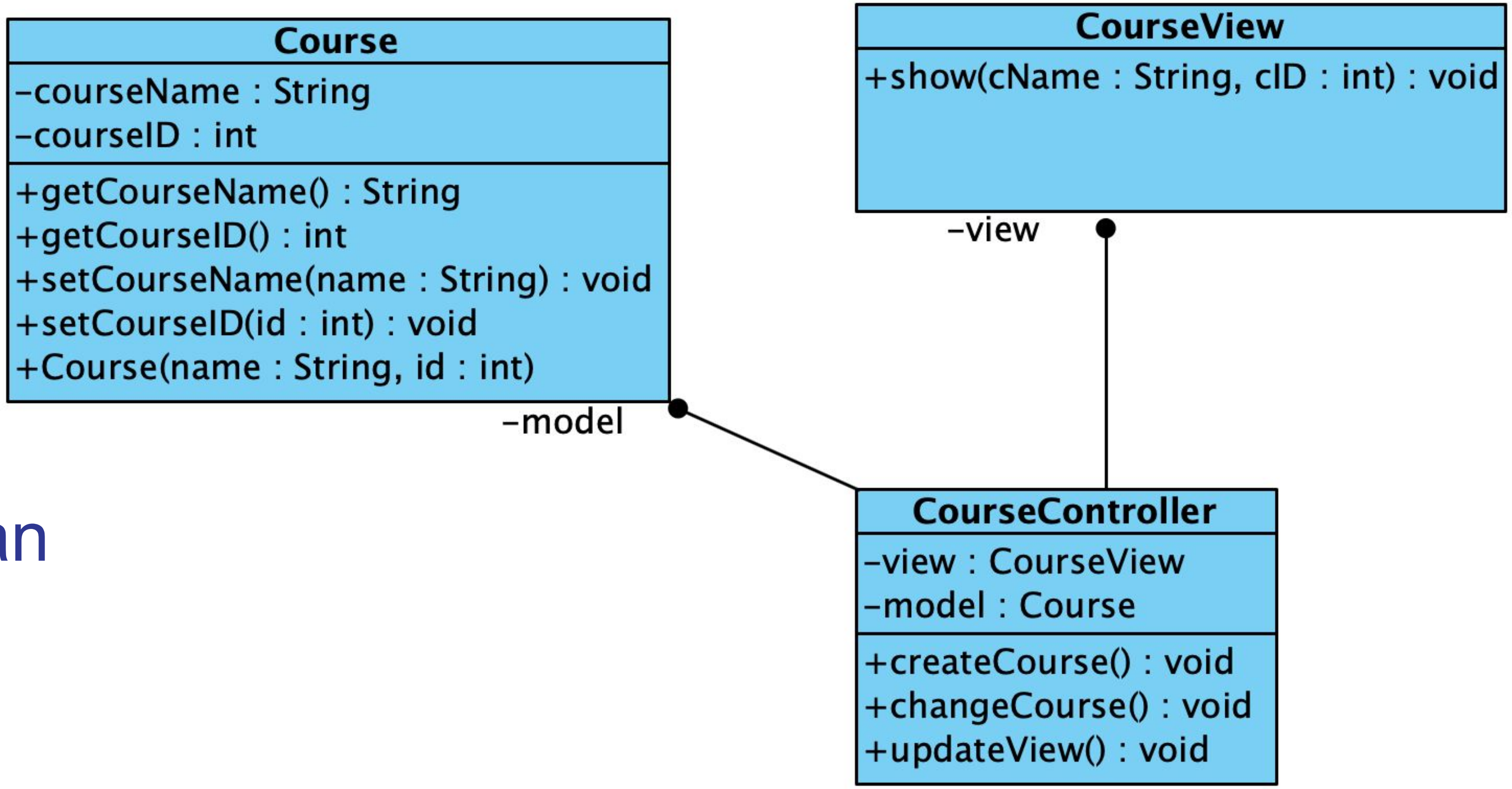
- Model designs based on MVC architecture follow the MVC design pattern and they separate the application logic from the user interface when designing software.
  - Model — Responsible for managing the data of the application. It responds to the request from the view and it also responds to instructions from the controller to update itself.
  - View — Defines the presentation of the application
  - Controller — Manages the flow of the application

Model View Controller

- MVC architecture offers a lot of advantages for a programmer when developing applications, which include:
  - Multiple developers can work with the three layers (Model, View, and Controller) simultaneously
  - Offers improved scalability, that supplements the ability of the application to grow
  - As components have a low dependency on each other, they are easy to maintain
  - A model can be reused by multiple views which provides reusability of code
  - Adoption of MVC makes an application more expressive and easy to understand
  - Extending and testing of the application becomes easy

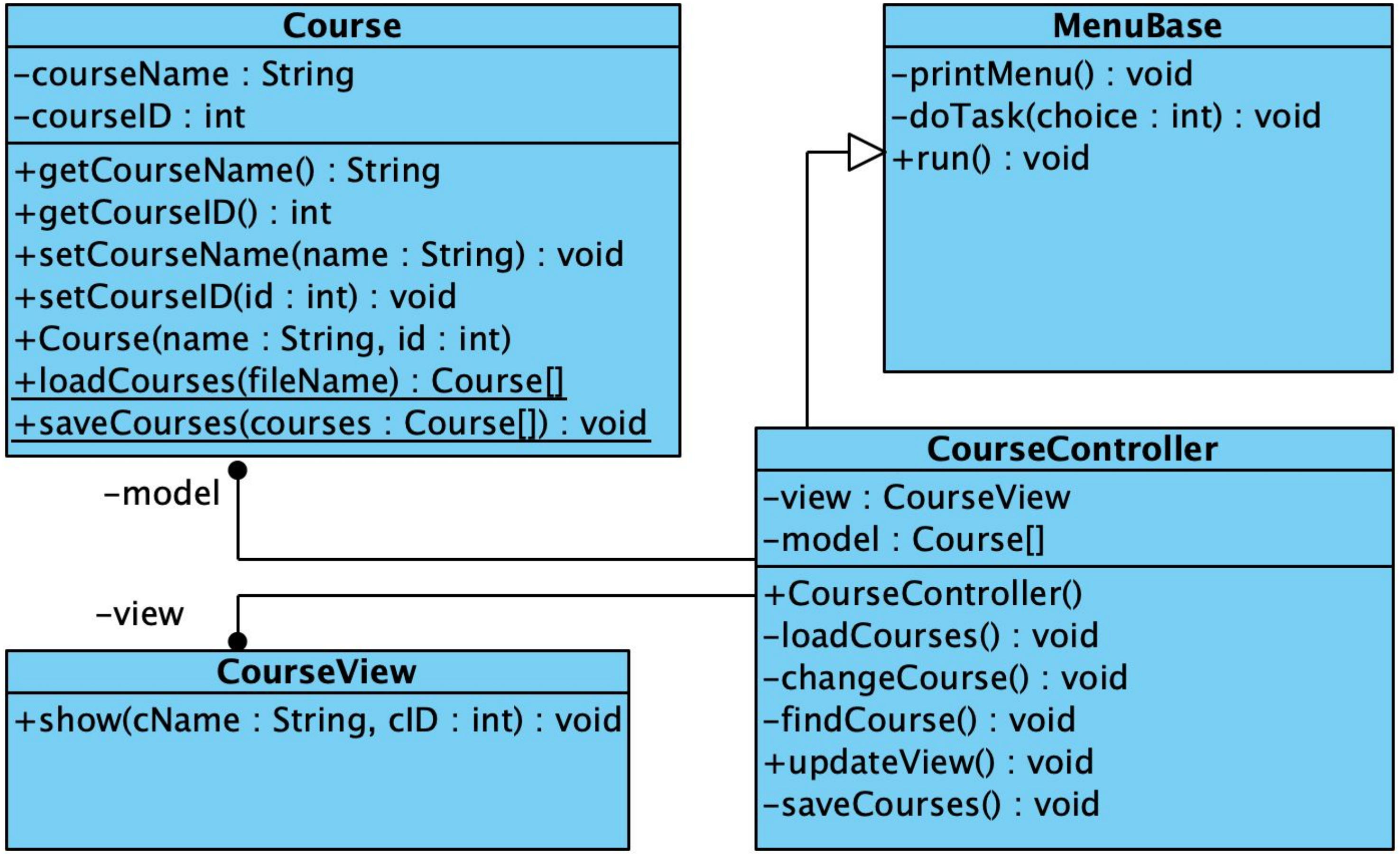
Simple Model View Controller Example

- Class Course is a simple model
- Class Controller is responsible for businesses: create a course, change a course
- Class CourseView can show a course to console



Model View Controller vs File

- Class Course
  - represents a model (course) and has responsible of working with data layer (file)
- Class CourseController inherits from MenuBase which runs by printing menu and do tasks based on user choice



Course

-courseName : String
-courseID : int

+getCourseName() : String
+getCourseID() : int
+setCourseName(name : String) : void
+setCourseID(id : int) : void
+Course(name : String, id : int)
+loadCourses(fileName) : Course[]
+saveCourses(courses : Course[]) : void

MenuBase

-printMenu() : void
-doTask(choice : int) : void
+run() : void

CourseController

-view : CourseView
-model : Course[]

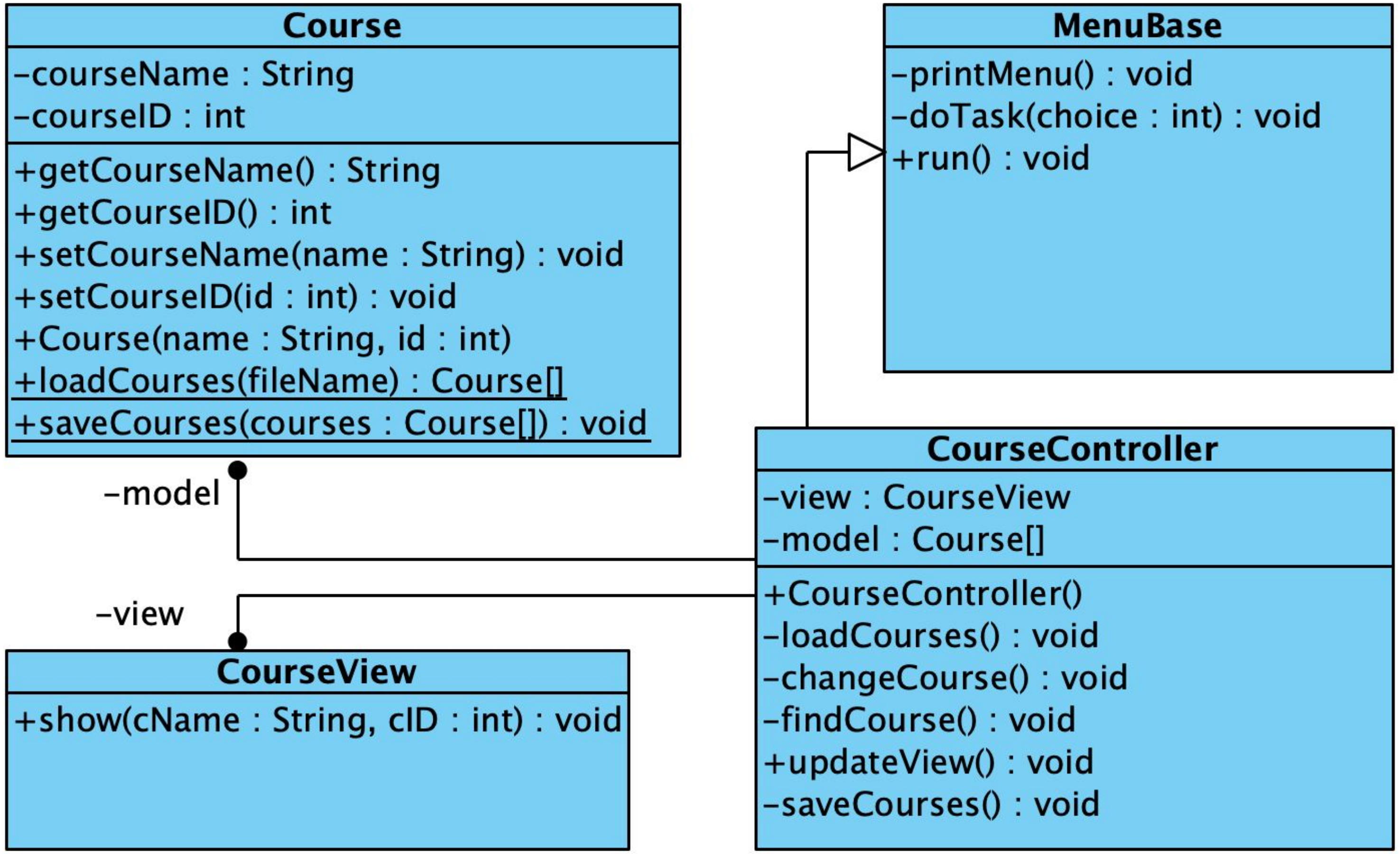
+CourseController()
-loadCourses() : void
-changeCourse() : void
-findCourse() : void
+updateView() : void
-saveCourses() : void

CourseView

+show(cName : String, cID : int) : void

Model View Controller vs File

- Class CourseController inherits from MenuBase which runs by printing menu and do tasks based on user choice
  - load/save courses from/to file
  - find a course
  - change a course


Course
-courseName : String
-courseID : int
+getCourseName() : String
+getCourseID() : int
+setCourseName(name : String) : void
+setCourseID(id : int) : void
+Course(name : String, id : int)
+loadCourses(fileName) : Course[]
+saveCourses(courses : Course[]) : void
MenuBase
-printMenu() : void
-doTask(choice : int) : void
+run() : void
-model
-view
CourseView
+show(cName : String, cID : int) : void
CourseController
-view : CourseView
-model : Course[]
+CourseController()
-loadCourses() : void
-changeCourse() : void
-findCourse() : void
+updateView() : void
-saveCourses() : void