CMSC 131: Chapter 6 (Supplement)
Introduction to Classes and Methods

Program Development

How do I build a program?

Software development lifecycle:

- **Analysis**: What is the problem to be solved?
- **Design**: What is the general structure of the program?
- **Implementation**: Write the Java code to implement your design.
- **Testing**: Check each piece you have written.
- **Maintenance**: Specifications have changed, bugs fixed, new enhancements added.

The "cycle": This is **not** a linear process.

Program Development Tips: Design

Analysis and Maintenance: No problem in CMSC 131. We give you the specifications.

Design: A good design strategy will save you enormous time in implementation and testing.

Stepwise Refinement:

Flowcharts:

Pseudo-code:

More Tips: Test and Implementation

Implementation and Testing:

Subtask Testing: As you complete the design of each task, write up a test implementation to see that your approach works.

Print: Use **System.out.println** to print intermediate results.

Hint: Don't delete these until you are done debugging.

Debugger: Allows you to step through your program line by line.

Save: your work in a safe place, say, after implementing and testing each major task.

Classes and Objects

Back to Java…Brief review:

- Each Java variable stores either a **primitive type** (int, float, etc) or a **reference to an object instance**.
- A **reference** is the "**address of**" or a "**pointer to**" an object instance.
- There is a special reference, **null**, that refers to no object.
- Unlike primitive types, each object instance must be **explicitly created** using the "**new**" operator.

- **Assigning** (=) one reference variable to another **copies the address**, not the object contents.
- **Comparing** two references (with ==) **compares the addresses**, not the contents.
- A **class** is a definition or "**blueprint**" for an object. A class encapsulates both **state** (data) and **behavior** (methods).

Anatomy of a Class

A **class** contains declarations of:

Instance data: which form the state (values) of the object
Methods: which determine the behavior of the object

Example: Date

To illustrate this we define a class, called **Date**, that stores a date object (month, day, and year).

Instance Data:

int month: Ranges from 1 to 12 (e.g. 1 = Jan, 2 = Feb, etc)
int day: Ranges from 1 to 31 (depending on the month)
int year: Four digit year (e.g. 2004)

Methods:

Date(int m, int d, int y): Creates a new Date object with the given month, day, and year.

toString( ): Returns a String representation of this date.

equals(Date d): Returns true if this date is the same as date d.

Example: Date.java (part 1)

```
/*
 * Date: An object that stores a date
 */

public class Date {

    private int month;          // the month (from 1-12)
    private int day;            // the day of the month (1-31)
    private int year;           // the year (four digits)

    /* Constructor method initializes a new Date object */
    public Date( int m, int d, int y ) {
        month = m;  day = d;  year = y;
    }

    // (insert part 2 here)
}
```

Creating a Date Object

A Date object is created using "new":

```
Date indepDay = new Date( 7, 4, 1776 );     // July, 4, 1776
```

This generates a call
to the constructor:

```
public Date( int m, int d, int y ) {
    month = m;  day = d;  year = y;
}
```

Example: Date.java (part 2)

```
/* Converts to a string */
public String toString( ) {
    return new String( month + "/" + day + "/" + year );
}

/* Is this date equal to another? */
public boolean equals( Date d ) {
    if ( ( year == d.year ) && ( month == d.month ) && ( day == d.day ) )
        return true;
    else
        return false;
}
```

String Conversion

Printing a Date object:

```
Date indepDay = new Date( 7, 4, 1776 );     // July, 4, 1776
System.out.println( "Independence day is " + indepDay.toString( ) );
```

This invokes the following method:

```
public String toString( ) {
    return new String( month + "/" + day + "/" + year );
}
```

Output: **Independence day is 7/4/1776**

In fact, the following works as well:

```
System.out.println( "Independence day is " + indepDay);
```

Comparing Dates for Equality

Example:

```
Date bobsBirthday = new Date( 7, 18, 1985 );  // July 18, 1985
Date carolsBirthday = new Date( 3, 23, 1985 ); // March 23, 1985
if ( bobsBirthday.equals( carolsBirthday ) ) …    // (false)
```

This invokes Bob's **equals** method:

```
public boolean equals( Date d ) {
    if ( ( year == d.year ) && ( month == d.month ) && ( day == d.day ) )
        return true;
    else
        return false;
}
```

Carol's birthday is the **actual parameter**. It is substituted for the **formal parameter** "d" in the method.

- year, month, day: Refer to **this** (Bob's) instance
- d.year, d.month, d.day: Refer to the **actual parameter** (Carol's) instance

Example: DateDemo.java

```
/* This file demos the Date class */

public class DateDemo {
    public static void main( String[ ] args ) {

        Date bobsBirthday = new Date( 7, 18, 1985 );          // July 18, 1985
        Date carolsBirthday = new Date( 3, 23, 1985 );        // March 23, 1985

        System.out.println( "His birthday is " + bobsBirthday.toString( ) );
        System.out.println( "Her birthday is " + carolsBirthday.toString( ) );

        if ( bobsBirthday.equals( carolsBirthday ) )
            System.out.println( "Same birthday" );
        else
            System.out.println( "Different birthdays" );
    }
}
```

Class Elements

The Date example shows many features of classes and methods:

- **Encapsulation** and **visibility** (private and public)
- Method **call** and **return**
- **Returning** values from methods
- Method **parameters** and parameter passing
- **Local data** and **scope**
- **Static** and **non-static** methods

Next, we investigate each of these issues in greater detail.

Visibility and Encapsulation

Two views of a car:

Driver's (External) view: (How to use it)

Mechanic's (Internal) view: (What makes it work)

Two views of an object:

Class user (**client**): sees the **public interface**.

Class implementer: sees all the class's data and methods.

Visibility and Encapsulation

Visibility Modifiers:

private:

public:

[protected]: We will discuss this later.

Example:

```
public class Modifiers {
   public  int  pubData;
   private int  privData;
   public  void pubMethod( ) { /* omitted */ }
   private void privMethod( ) { /* omitted */ }
}

public class ModifierDemo {
   public static void main( String[ ] args ) {
         Modifiers mod = new Modifiers( );
         mod.pubData = 1;              // Okay: pubData is public
         mod.pubMethod( );             // Okay: pubMethod is public
         mod.privData = 1;             // Illegal! privData is private
         mod.privMethod( );            // Illegal! privMethod is private
   }
}
```

Visibility: Guidelines

What should be visible and what not?

Data instances should be private:

Example: month could reasonably be any of the following…

int from 1-12:

int from 0-11:

String: "Jan", "Feb", …

Exception: **Constants** can be made public. The modifier **final** means that a variable is a constant, and its value cannot be changed.

```
public final int DAYS_PER_WEEK = 7;
```

Visibility: Guidelines

What should be visible and what not?

Methods in the public interface are public:

Utility/Support methods should be private:

Conventions: Methods are often further distinguished by their general function.

Accessors:

Mutators:

Examples: Possible additional methods for the Date class:

Accessor: `int getMonth( ) { return month; }`

Mutator: `void incrementYear( ) { year++; }`

Method Call and Return

When a method is invoked (or "**called**"), control jumps into the method. Control returns when:

- Control reaches the **end of the method**, or
- A "**return**" statement is explicitly executed

Return statements can be placed throughout a method.

Method Return Types and "void"

A **method** can either:

Return a value:

Return no value:

The special type "**void**" means that the method returns no value.

Examples: (Parameters and method bodies omitted)

```
public String toString( )              // returns a String reference
public boolean equals( … )             // returns a boolean
private double getPressure( … )        // returns a double
public void printHelp( )               // returns no value
private void changeAddress( … )        // returns no value
```

Methods and Parameter Passing

Information is passed into a method through a list of **parameters**. When defining a method, a list of **formal parameters** and their types is given:

```
public void doSomething( double w, int x, String y) { … }
```

To call the method, the corresponding **actual parameters** are given.

```
int count = 53;
doSomething( 1.25, count+2, "Hello" );
```

Parameter Passing: These are copied to the **formal parameters**. Types must be compatible.

```
public void doSomething( double w, int x, String y ) {
   System.out.println( w + " " + x + " " + y );
}
```

Pass by Value:

Static and non-Static Methods

Consider the following class method calls:

```
String s = JOptionPane.showInputDialog( "Input an integer" );
Date bastilleDay = new Date( 7, 14, 1789 );
int y = Integer.parseInt( s );
double c = Math.sqrt( (double) y );
int x = s.length( );
String t = bastilleDay.toString( );
```

Note that these are of two basic types:

The last two apply to a **particular object instances** of a class:

```
int x = s.length( );
String t = bastilleDay.toString( );
```

The others do not reference **any** particular object (just the class):

```
String s = JOptionPane.showInputDialog( "Input an integer" );
int y = Integer.parseInt( s );
double c = Math.sqrt( (double) x );
```

Static and non-Static Variables

Static variable:

.

For example, in our Date class we might add:

```
static public final int DAYS_PER_WEEK = 7;
static public final int MONTHS_PER_YEAR = 12;
```

These could then be accessed outside the class as:

Date.DAYS_PER_WEEK and **Date.MONTHS_PER_YEAR**

Static and non-Static Methods

Static methods:

Example: A method for the Date class that determines whether a given year is a **leap year**. The parameter will be an integer year, yr.

Leap Year: A year is a leap year if:

Leap Year Method Example

```
public class Date {
    private int month;
    private int day;
    private int year;

    public Date( int m, int d, int y ) { … }
    public String toString( ) { … }
    public boolean equals( Date d ) { … }

    /* Is the given year a leap year?  */
    public static boolean isLeapYear( int yr ) {
        boolean answer;
        if        ( (yr % 400) == 0 )  answer = true;      // multiple of 400
        else if   ( (yr % 100) == 0 )  answer = false;     // multiple of 100
        else if   ( (yr %   4) == 0 )  answer = true;      // multiple of 4
        else                           answer = false;     // not a multiple of 4
        return answer;
    }
}
```

Error Checking in Constructor

Error Checking: Let us add to the constructor a check for days that are out of range and issue a warning message. To do this, we will add a new method lastDayOfMonth( ):

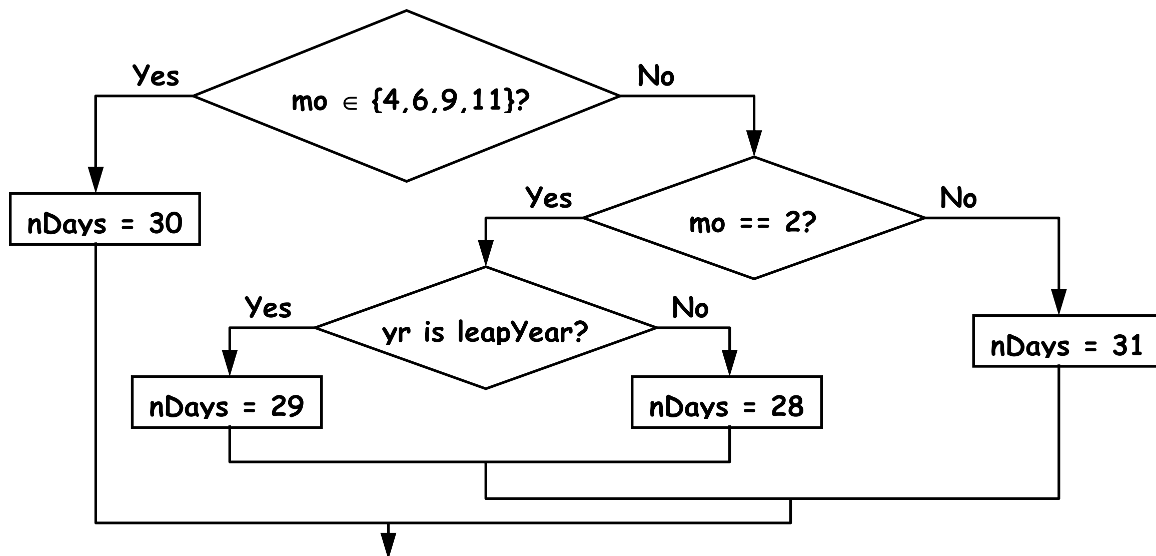
```
/* Revised Date constructor with day check */
public Date( int m, int d, int y ) {
    month = m;  day = d;  year = y;
    if ( d < 1 || d > lastDayOfMonth( m, y) )
        System.out.println( "Warning: day is out of range" );
}
```

lastDayOfMonth(int mo, int yr) : This utility function returns the (int) last day of the given month.

Utility Method lastDayOfMonth

lastDayOfMonth(int mo, int yr) : Returns the last day of the given month.

Design: "30 days hath September, April, June and November…"



Utility Method lastDayOfMonth

```
public class Date {
    private int month;
    private int day;
    private int year;

    public Date( int m, int d, int y ) { … }
    public String toString( ) { … }
    public boolean equals( Date d ) { … }
    public static boolean isLeapYear( int yr ) { …)

    private static int lastDayOfMonth( int mo , int yr ) {
        int nDays;
        if ( mo == 4 || mo == 6 || mo == 9 || mo == 11 )
            nDays = 30;
        else if ( mo == 2) {
            if (isLeapYear( yr ) ) nDays = 29;
            else nDays = 28;
        } else {
            nDays = 31;
        }
        return nDays;
    }
}
```