Object Oriented Design: Classes and Objects

Overview

- Defining a class creates a new object type with the same name.
- Every object belongs to some object type; that is, it is an instance of some class.
- An object is a ***synthesis*** of attributes (data) and behaviors (methods), bundled into a single structure.
- A class definition is the blueprint for an object: it specifies what attributes the objects have and what methods can operate on them as well as what is visible to the outside world.
- The methods that operate on an object type are defined in the class for that object.
- The **new** operator instantiates objects, that is, it creates new instances of a class and returns a reference to the instance.

As we know, an ***object-oriented*** program is a collection of interacting objects, where each object is a separate module that encapsulates a portion of the program's attributes and actions. Objects are defined in a structure called a ***class***, which serves as a template or blueprint for creating objects. Think of the cookie cutter analogy. A class is like a cookie cutter. Just as a cookie cutter is used to shape and create individual cookies, a class definition is used to shape and create individual objects. Another great analogy is a blueprint and a house. You first ***model*** the house by creating the blueprint. Once you have the blueprint flushed out you can build infinite houses from that blueprint.

You have seen this in the objects we have used so far: The String class is a perfect example. A main attribute of the String class is the character data that defines the String's text. A behavior of the String class would be methods such as ***indexOf, substr*** and ***length.*** These methods operate on the underlying String data. The method signatures define what messages can be passed to an object, and what an object can do.

Programming in an ***object-oriented paradigm*** is primarily a matter of designing class definitions to represent real-world objects, which are then used to construct objects. The objects perform the program's desired actions. To push the cookie cutter analogy a little further, designing and defining a class is like building the cookie cutter. Obviously, very few of us would bake cookies if we first had to design and build the cookie cutters. We'd be better off using a pre-built cookie cutter. By the same token, rather than designing our own classes, it will be easier to get into "baking" programs if we begin by using some predefined Java classes, and once we have a nice robust library of our own, we can reuse these objects in future projects.

So far you have gotten experience creating and interacting with various objects from the Java API

- String
- array
- Scanner
- File
- FileReader
- BufferedFileReader
- And many others you may have researched and implemented.

These objects are all built from their associated class definitions. Once the objects have been constructed and initialized, we communicate with them by calling methods and passing arguments; colloquially called ***message passing***. We discovered the details of the object's interface by studying the Java API specification. We can also build our own API specification for the objects that we design. It's crucial to provide other programmers with a way to easily determine details of our object's interface.

We will now examine how to create our own classes and objects and Java style API documentation. We will also develop some UML diagramming techniques along the way.

Let's begin by modeling a Date class that will be used to store and process basic Date data. Dates are used and reused in numerous contexts. Most programming languages already have a fully functional Date implementation, ***but from an academic standpoint it is a good example to flush out***.

When first designing a class, we begin with some abstraction. As the work continues on the class, more and more details will be filled in until we have a working, tested and secure definition

For each object, we must answer the following basic design questions:

- What role will the object perform in the program?
- What data or information will it need?
- What actions will it take?
- What interface will it present to other objects?
- What information will it hide from other objects?

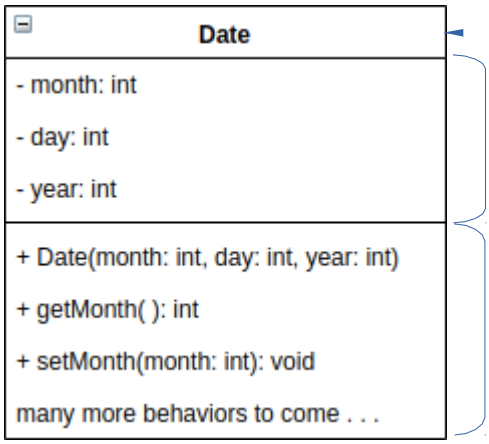
For our Date object, the answers to these questions are shown below. Note that although we talk about "designing an object," we are really talking about designing the object's class. A class defines the collection of objects that belong to it (the object's ***classification***). The class can be considered the object's ***type***. This is the same as for real-world objects. Thus,

- Seabiscuit is a horse—that is, Seabiscuit is an object of type horse.
- Legolas is an elf – that is, Legolas is an object of type elf
- Aragorn is a human – that is, Aragorn is an object of type human
- Bilbo is a halfling – that is, Bilbo is an object of type halfling

Similarly, an individual Date, such as **12/31/1999** is a Date. That is, it is an object of type Date.

Class Name	Date
Role	To store, retrieve and process months, days and years as a single mutable object
Attributes	month, day and year. There could be many more, these are just the obvious choices.
Behaviors	create a Date, retrieve and modify the attributes, perform some basic Date math (adding Dates together, subtracting Dates, . . . etc

The Unified Modeling Language has a standardized set of graphical objects to represent class design. Here is the beginning of our basic Date class design in UML.



Class Name: Object data type
Attributes: Non-static ***instance*** variables
Behaviors: Methods
Access Modifiers: The + and – notation in UML defines access: ***public (+) or private (-).*** These access modifiers allow us to expose features available to class consumers and hide features that are for internal usage only, or important memory allocation that we wish to protect from potential modification.

Instance Variables:

We will define storage for the attributes: **month, day and year** in special variables called ***instance variables***. These are also known as **member variables** . . . as in **member of the class.** An instance variable is a variable for which ***each instantiated object*** of the class owns a separate copy, or instance. Whenever a new object is created from the class definition, new copies of these variables will be created. The variables will be accessible to all internal object methods regardless of the access modifier.

Instance methods are defined at ***class level scope,*** that is, inside the class but outside of any method definition. This scope allows access to all methods in the class.

Object Oriented Principle: Encapsulation and Information Hiding

In object-oriented programming (OOP), encapsulation refers to the bundling of data with the methods that operate on that data, and the restricting of direct access to some of an object's components. Put simply, encapsulation is about ***hiding complexity***. In the real world, objects frequently hide their information and how they work. You don't need to know the internal details in order to use an object. For example, you don't need to understand how a gasoline-powered internal combustion engine works in order to drive a car. By extension, you should be able to drive a car that uses another fuel source or an electric motor without knowing how each of those work either. When you create an object in an object-oriented language, you can hide the complexity of the internal workings of the object. As a developer, there are two main reasons why you would choose to hide complexity. Another example is the Java 2D Graphics object. That class hides all of the details of the actual painting of pixels on the screen. There is no need for us to care about those details if we are simply trying to draw something.
The first goal of encapsulation is to provide a simplified and understandable way to use your object without the need to understand the complexity inside. As mentioned above, a driver doesn't need to know how an internal combustion engine works. It is sufficient to know how to start the car, how to engage the

transmission if you want to move, how to provide fuel, how to stop the car, and how to turn off the engine. You know to use the key, the shifter (and possibly clutch), the gas pedal and the brake pedal to accomplish each of these operations. These basic operations form the interface for the operation of the car. Think of an interface as the collection of things you can do to the car without knowing how each of those things works. Another good example is a microwave oven . . . you do not need to understand the physics of radiation in order to heat up your cheese dip. You just program the time by pressing buttons and then press start.

Hiding the complexity of the car from the user allows anyone, not just a mechanic, to drive a car. In the same way, hiding the complex functionality of your object from the user allows anyone to use it and to find ways to reuse it in the future regardless of their knowledge of the internal workings. This concept of keeping implementation details hidden from the rest of the system is key to object- oriented design.

The second reason for hiding complexity is to manage change. Today most of us who drive use a vehicle with a gasoline-powered internal combustion engine. However, there a gas-electric hybrids, pure electric motors, and a variety of internal combustion engines that use alternative fuels. Each of those engine types has a different internal mechanism yet we are able to drive each of them because that complexity has been hidden. This means that, even though the mechanism which propels the car changes, the system itself functions the same way from the user's perspective.

Imagine a relatively complex object that parses an audio file and yet allows you only to play, seek or stop the playback. Over time, the author of this object could change the internal algorithm of how the object works completely; new optimization for speed could be added, memory handling could be improved, additional file formats could be supported, and the like. However, since the rest of the source code in your application uses only the ***play, seek and stop methods***, this object can change significantly internally while the remainder of your application can stay exactly the same. This technique of providing encapsulated code is critical in team environments.

Encapsulation is used to hide the values or state of a structured data object inside a class, preventing unauthorized parties' direct access to them. Publicly accessible methods are generally provided in the class (so-called "getters" and "setters") to access the values, and other client classes call these methods to retrieve and modify the values within the object. In object-oriented programming languages, encapsulation refers to one of two related but distinct notions, and sometimes to the combination thereof:

Encapsulation

- A language mechanism for restricting direct access to some of the object's components. Java provides the access modifiers: ***public, private*** and ***protected***
- A language construct that facilitates the bundling of data with the methods operating on that data. Java provides the class structure
- Many languages provide these features.

To properly restrict access to encapsulated variables we define the access as ***private*****.** A feature marked private is only accessible ***within*** the class in which it is defined. This allows programmers to strictly define the ways in which a member feature can be modified.

In the Date example we would want to restrict access to the instance variables: **day, month and year** because there are strict domains that govern the values that should be allowed for each variable. Restricting the access allows us to strictly control data that comes into the class.

Domain: a set of allowable values for a variable

Date Domains:

- day => the set of integers {1 – 31}
- month => the set of integers {1 – 12}
- year => the set of integers {1000 – 9999} or whatever your context requires.

We need to ensure that these domains are enforced at all times. The first step in enforcing this requirement is to ***turn off public access*** to the features.

```
1  public class Date{
2
3      // Class Level Instance Variables
4      // each new Date instance will get unique copies of these variables
5      private int month;
6      private int day;
7      private int year;
8  } // end class
```

By applying the **private** access modifier to a variable, we restrict its access to **inside the class.** This will prevent any unauthorized external modification of these variables. Let's see what this looks like by creating an instance of this Date class. I will do this in a separate class called a **Driver.** Creating a separate testing class is common. This driver class will have the main method (notice that there is no main method in Date). To obviate any further configuration, it is important that the files: **Date.java** and **DateDriver.java** be saved into the ***same directory***. Java does not require import statements for files that are in the same directory (as long as your CLASSPATH variable contains the ***current directory*** "." reference

```
1  public class DateDriver{
2
3      public static void main(String[] args){
4
5          // create a Date instance using the default constructor
6          Date d = new Date();
7
8          // attempt to modify the month variable
9          d.month = 27;
10     }
11 }
```

```
PROBLEMS   OUTPUT   DEBUG CONSOLE   TERMINAL

kenneth@dragonborn:~/OneDrive/Spring2020/165/examples/Date_class$ javac DateDriver.java
DateDriver.java:9: error: month has private access in Date
        d.month = 27;
          ^
1 error
```

Notice that the compiler complains about our attempt to access a private variable. Hopefully you see the utility of this as I tried to set the month to the invalid value of 27. So how do we set a value of a month? Obviously, we need some way to tell the instance what its ***month, day and year*** values should be.

Instance Methods

A method in OOP is a procedure associated with a message and an object. An object consists of data and behavior. The data and behavior comprise an interface, which specifies how the object may be utilized by any of various consumers of the object. Methods also provide the **interface** that other classes use to access and modify the data properties of an object. This is an aspect of encapsulation. Unlike instance variables, there exists only a single definition of a method. The method is then associated with the correct object by the object's reference. The JVM handles this association, and we need not concern ourselves with the details at this point.

Getters and Setters

One convention of object-oriented programming is to provide public methods to set and get the values of some of its private instance variables. Methods that set or modify an object's instance variables are called **mutator** methods (**setter methods**). Methods that get or retrieve the value of an instance variable are called **accessor** method (**getter methods**). These are the companion methods that allow consumers the ability to interact with the instance variables. Getters allow for the value of an instance variable to be gotten or retrieved. Setters allow for an external value to be passed into the class. Setter methods allow us to provide some domain validation before setting the value.

It is up to the designer of the class to determine which private variables require getter and setter methods. If you were designing a BankAccount class, you might want a public ***getAccountNumber()*** method, so that clients could retrieve information about their bank accounts, but you would probably not want a public ***getAccountPassword()*** method or a public ***setAccountBalance()*** method. Context always dictates the methods that need to be defined. You need to thoroughly understand the problem before beginning any coding.

In general (though not ALWAYS)

- a setter method will be void and accept an argument. If the argument passes inspection, its value will be applied to the private instance variable
- a getter method will be non-void and not accept an argument. Getters simply return the values of instance variables.

Note: This method mutates the value of the private instance variable **month.** This type of action is called a **side effect . . .** the method has the side effect of changing the value of variable of a different scope. The local instance variable ***month*** is only assigned if the parameter ***m*** passes our domain validation. What happens if the domain validation fails is up to your team. For simplicity purposes I will simply leave it alone. You may envision a better approach.

```
/**
 * Validates and sets the month. Month will be left alone if invalid
 *
 * @param month The integer month to be set
 */
public void setMonth(int month){
    // perform some domain validation
    if(month >= 1 && month <= 12)
        this.month = month;
}
```

Java Instance Methods: Method definition consists of a method signature and a method body. The signature defines its access, ownership, return type, name and formal parameter list.

```
public static int methodName(int a, int b){
        // method body
}
```

Here:

- **public:** method is available outside of this class
- **static:** method belongs to the class, not instances of the class
- **int:** return type. Method returns an int
- **methodName:** the name of the method
- **int a, int b:** parameters to the method

Now that we have a setter method associated with an instance variable, we can send our Date object a message to set this value, along with the value we wish to be set. Because the data is now passed through a method, we force the external data through our domain validation. In this example our domain of valid months **{1 – 12}** is being tested. If the argument is within the domain set it is allowed. If it falls outside the domain set, the value will be set to some default value, or left alone.

```
1   public class DateDriver{
2
3       public static void main(String[] args){
4
5           // create a Date instance using the default constructor
6           Date d = new Date();
7
8           // tell d to set it's month value
9           d.setMonth(12);
10      }
11  }
```

Method call

Let's add a getter method to retrieve the value of month. The ***getMonth()*** method is required if we wish to allow access to the month value. You do not have to define getters and setters for a value if your context does not need this behavior.

```
/**
 * Returns the current month
 *
 * @return this.month
 */
public int getMonth(){
    return month;
}
```

Let's test these methods in our ***DateDriver*** class.

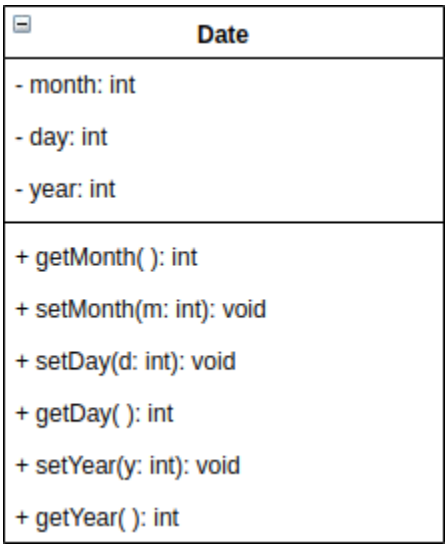
```
1  public class DateDriver{
2
3      public static void main(String[] args){
4
5          // create a Date instance using the default constructor
6          Date d = new Date();
7
8          // tell d to set it's month value
9          d.setMonth(12);
10
11         // tell d to give use its month
12         int m = d.getMonth();
13
14         System.out.println("The month is: " + m);
15     }
16 }
```

Method calls . . . setters are void and getters return values

```
PROBLEMS  OUTPUT  DEBUG CONSOLE  TERMINAL

kenneth@dragonborn:~/OneDrive/Spring2020/165/examples/Date_class$ javac DateDriver.java
kenneth@dragonborn:~/OneDrive/Spring2020/165/examples/Date_class$ java DateDriver
The month is: 12
```

The full code listing fcan be found in the repository. Pay close attention to the public and private features. The public features form the object's interface and the private instance variables maintain the object's state. The principle of ***information hiding*** dictates this.

The UML class diagram for our Date class now looks like this.



The toString Method

There are a variety of methods that are ***expected*** to exist in our class designs. As we proceed through the course these methods will present themselves. The most basic method is **toString**. This method exists to create a nicely formatted String representation of our object's **state.**

State: An object's state is the current value of all relevant attributes (instance variables). The state of the instance shown below is

Attribute	Value
Month	1
Day	2
Year	2020

The ***toString*** method allows programmers to dictate how their objects are treated by output routines like **System.out.println.** Let's see what we can do so far

```
1   public class DateDriver{
2
3       public static void main(String[] args){
4
5           // create a Date instance using the default constructor
6           Date d = new Date();
7
8           // set d to 1/2/2020
9           d.setMonth(1);
10          d.setDay(2);
11          d.setYear(2020);
12
13          System.out.println("The date is: " + d);
14      }
15  }
```

```
PROBLEMS   OUTPUT   DEBUG CONSOLE   TERMINAL
kenneth@dragonborn:~/OneDrive/Spring2020/165/examples/Date_class$ javac DateDriver.java
kenneth@dragonborn:~/OneDrive/Spring2020/165/examples/Date_class$ java DateDriver
The date is: Date@4b1210ee
```

You should recognize this output as being the ***Class type of object "d" followed by its hash code***. This doesn't do us much good. We could format the the date ourselves by calling the get methods and applying formatting, but this would be tedious to perform every time and would not be convenient for class consumers. It would be better to define this behavior as part of the Date class. This is what the **toString** method is for. Here is the toString for the Date class.

```
40      public String toString(){
41          return month + "/" + day + "/" + year;
42      }
```

Adding this to our Date class changes the Driver behavior without us having to change the Driver code at all (another benefit of information hiding). This is because the JVM automatically calls the **toString** on an object anytime it is placed in a String context. **Due to this it is important that your toString signature be exact!**

toString cannot be

- ToString
- to_string
- or any other spelling

```
1   public class DateDriver{
2
3       public static void main(String[] args){
4
5           // create a Date instance using the default constructor
6           Date d = new Date();
7
8           // set d to 1/2/2020
9           d.setMonth(1);
10          d.setDay(2);
11          d.setYear(2020);
12
13          System.out.println("The date is: " + d);
14      }
15  }
```

```
PROBLEMS   OUTPUT   DEBUG CONSOLE   TERMINAL

kenneth@dragonborn:~/OneDrive/Spring2020/165/examples/Date_class$ javac DateDriver.java
kenneth@dragonborn:~/OneDrive/Spring2020/165/examples/Date_class$ java DateDriver
The date is: 1/2/2020
```

The equals method

Another required method is the equals method. Saying “required” is a bit of a stretch here because it is not always necessary to be able to compare two objects. For the Date class it is necessary because comparing two dates is a common operation.

For instance, if you were writing an application to track rentals you would need to be able to ask questions like

- How many days until this item is due?
- Was this item returned before the due date?
- Did the shipment arrive by the advertised shipping date?
- We’ll learn how to order dates when we study the comparable pattern

The default equality operator (==) only works on ***primitive values***. Object references are primitive integers. If two Date objects have the **same state** but are physically distinct objects residing at different addresses, comparison using == will return false. This is not the behavior we want.

Remember: Comparing objects with == is a ***shallow comparison*** and only tests the references and will return true if the object is aliased by multiple references.

The purpose of the equals method is to provide a routine to perform a ***deep comparison***. This type of comparison will cycle through the instance variables performing appropriate comparisons on each. This usually takes the form of a compound boolean "and" expression.

Examine the following Driver output to see why we need an equals method.

```
1   public class DateDriver{
2
3       public static void main(String[] args){
4
5           // create a Date instance using the default constructor
6           Date d = new Date();
7           Date d2 = new Date();
8
9           // set d to 1/2/2020
10          d.setMonth(1);
11          d.setDay(2);
12          d.setYear(2020);
13
14          // set d2 to 1/2/2020
15          d2.setMonth(1);
16          d2.setDay(2);
17          d2.setYear(2020);
18
19          if(d == d2) System.out.println(d + " equals " + d2);
20          else System.out.println(d + " does not equal " + d2);
21      }
22  }
```

```
PROBLEMS   OUTPUT   DEBUG CONSOLE   TERMINAL

kenneth@dragonborn:~/OneDrive/Spring2020/165/examples/Date_class$ javac DateDriver.java
kenneth@dragonborn:~/OneDrive/Spring2020/165/examples/Date_class$ java DateDriver
1/2/2020 does not equal 1/2/2020
```

Equals method syntax

Access:	public
Return Type:	boolean
Name:	equals
Argument:	Instance of the class you are comparing

Note: Custom objects can be passed to methods just like any other data. When you do this you are passing the **reference** into the method. The object then becomes aliased by the local argument identifier. You can call methods on this object through the alias. If you are in the **same class** as the one that defines the object, you can also manipulate private members.

```
public boolean equals(Date d){
    return  this.day    == d.day    &&
            this.month  == d.month  &&
            this.year   == d.year;
}
```

Notice that we can directly access d's instance variables **because this code is in the same class**, therefore we are not violating privacy as we are in direct control of the source.

Adding this method definition to our class gives us the ability to perform **deep comparisons.** Let's see this in action

```
 9          // set d to 1/2/2020
10          d.setMonth(1);
11          d.setDay(2);
12          d.setYear(2020);
13
14          // set d2 to 1/2/2020
15          d2.setMonth(1);
16          d2.setDay(2);
17          d2.setYear(2020);
18
19          // test using ==
20          System.out.print("Using == ");
21          if(d == d2) System.out.println(d + " does equal " + d2);
22          else System.out.println(d + " does not equal " + d2);
23
24          // test using equals method
25           System.out.print("Using .equals ");
26          if(d.equals(d2)) System.out.println(d + " does equal " + d2);
27          else System.out.println(d + " does not equal " + d2);
28      }
29  }
```

```
PROBLEMS   OUTPUT   DEBUG CONSOLE   TERMINAL

kenneth@dragonborn:~/OneDrive/Spring2020/165/examples/Date_class$ javac DateDriver.java
kenneth@dragonborn:~/OneDrive/Spring2020/165/examples/Date_class$ java DateDriver
Using == 1/2/2020 does not equal 1/2/2020
Using .equals 1/2/2020 does equal 1/2/2020
```

The “this” keyword

If you were paying close attention, you noticed the **“this”** keyword in the equals method. “This” is colloquially known as a reference ***to the current object.*** In this case, the current object is the one through which we called the equals method . . . ***the object the method was invoked upon***. We can call **this** the **calling object.** I used this to draw attention to the different instance variables being compared. Remember, each instance has its own copies of these variables, and we need to be specific with our references. One “**day”** variable belongs to the argument **d**, the other day variable belongs to the instance through which we called equals . . . **this**.

```
public boolean equals(Date d){
    return  this.day    == d.day    &&
            this.month  == d.month  &&
            this.year   == d.year;
}
```

In our example **this** refers to instance **d *in the Driver*** while Date d in the equals method refers to instance **d2 *in the Driver***. This association is created by

- The object you use to call the method (d)
- The object you pass as an argument to the method (d2)
- This ordering and aliasing is crucial to understand

Constructors

As it stands, we only have one way to pass values into our Data class: the setters. This requires 4 lines of code to create and initialize a Date object

```
// create a Date instance using the default constructor
Date d = new Date();
Date d2 = new Date();

// set d to 1/2/2020
d.setMonth(1);
d.setDay(2);
d.setYear(2020);

// set d2 to 1/2/2020
d2.setMonth(1);
d2.setDay(2);
d2.setYear(2020);
```

This is tedious and cumbersome. Luckily OO languages provide a special method for building instances: the ***Constructor***. A class’ constructors are invoked to create objects from the class blueprint. Constructor declarations look like method declarations—except that they use the name of the class and have no return type. We have already seen a constructor for our Date class . . . the default constructor.

Default Constructor: If no constructor is explicitly defined in a class, the java compiler will provide one that accepts no arguments and performs no initialization.

Notice that we did not define a constructor but were still able to construct instances. Thank you default constructor! But as we have seen, we need to provide convenient methods of instantiation. Let's define our own constructor . . . one that will allow us to provide initialization code. One that will allow us to pass in the values of month, day and year on the same line as our object creation. Something like this

```
// create a Date instance using custom constructor
Date d = new Date(1, 2, 2020);
```

The signature of this constructor in our Date class will be:

```
public Date(int month, int day, int year){
```

Constructor Rules:

1. They have the same name as the class
2. They do not have a return type
3. They can accept arguments like any other method
4. They should be public, unless you want to ***prohibit object creation***. This is a thing. Try to create an instance of the Math class . . . I dare you. Let me know how it goes.

Constructors can set instance variables just like regular methods. So we could define our Date constructor like this (**this.month** refers to the class level instance variable and allows us the ability to distinguish between the argument and the instance variable)

```
public Date(int month, int day, int year){

    this.month  = month;
    this.day    = day;
    this.year   = year;

}
```

But this would bypass all the domain validation we performed in our setter methods. Given the rule of programming

NEVER REPEAT YOURSELF

How can we validate a constructor's input? We can simply have the constructor call our domain validation methods.

```
public Date(int month, int day, int year){
    // call setter methods to route
    // constructor args through domain validation
    setMonth(month);
    setDay(day);
    setYear(year);
}
```

Let’s try this out with our existing driver

```
1   public class DateDriver{
2
3       public static void main(String[] args){
4
5           // create a Date instance using custom constructor
6           Date date = new Date(1, 2, 2020);
7
8
9           Date d = new Date();
10          Date d2 = new Date();
11
```

PROBLEMS OUTPUT DEBUG CONSOLE TERMINAL

```
kenneth@dragonborn:~/OneDrive/Spring2020/165/examples/Date_class$ javac DateDriver.java
DateDriver.java:9: error: constructor Date in class Date cannot be applied to given types;
        Date d = new Date();
                 ^
  required: int,int,int
  found:    no arguments
  reason: actual and formal argument lists differ in length
DateDriver.java:10: error: constructor Date in class Date cannot be applied to given types;
        Date d2 = new Date();
                  ^
  required: int,int,int
  found:    no arguments
  reason: actual and formal argument lists differ in length
2 errors
```

You’ll notice that we get 2 errors when compiling this code. These errors have to do with code that we compiled and executed before . . . with no errors. Huh?

Note about default constructors: The default constructor is only supplied when you do not write a constructor yourself. When you do write your own constructor the **java compiler does not provide one.** Closely read the error messages.

If you don’t want your earlier code to break you can provide an additional constructor that has that signature. This constructor is called the ***no argument constructor*** and generally looks like this.

```
public Date(){} // no argument constructor
```

You can have multiple constructors in the same class as long as the signature is different. This is called ***overloading*** and also applies to instance methods. This will be covered in more detail in a subsequent document.

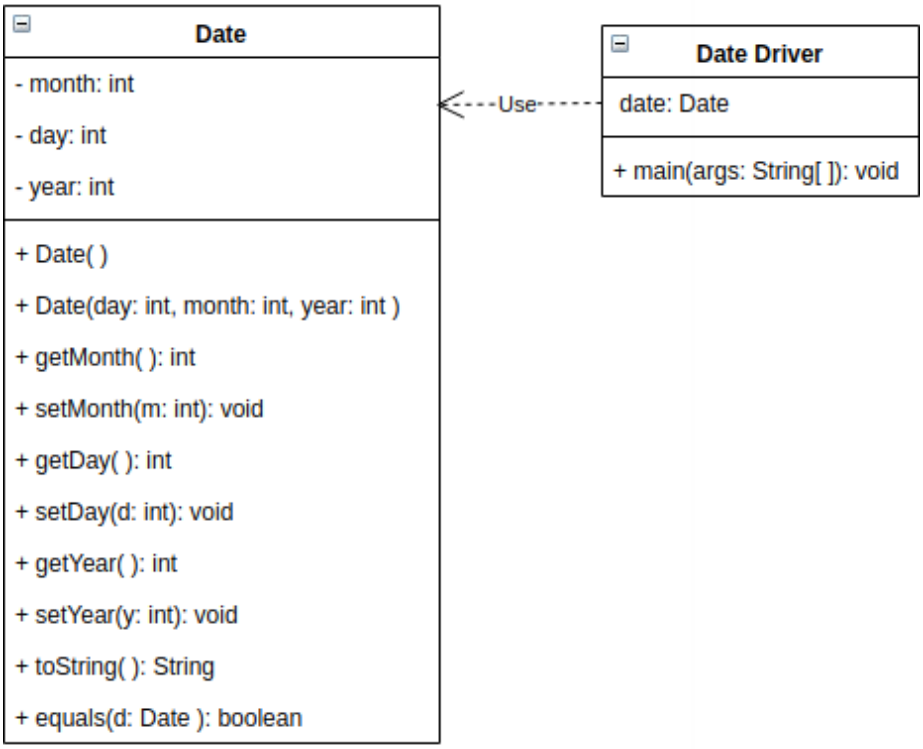
```java
public class Date{

    // Class Level Instance Variables
    private int month;
    private int day;
    private int year;

    public Date(){} // no argument constructor

    public Date(int month, int day, int year){
        // call setter methods to route
        // constructor args through domain validation
        setMonth(month);
        setDay(day);
        setYear(year);
    }
```

The previous driver code now compiles error free. These multiple constructors are for convenience to any consumer who may interact with our class. Which constructors you define are up to your team.

```java
public class DateDriver{

    public static void main(String[] args){

        // create a Date instance using custom constructor
        Date date = new Date(1, 2, 2020);

        Date d = new Date();
        Date d2 = new Date();

```

```
PROBLEMS  OUTPUT  DEBUG CONSOLE  TERMINAL

kenneth@dragonborn:~/OneDrive/Spring2020/165/examples/Date_class$ javac DateDriver.java
kenneth@dragonborn:~/OneDrive/Spring2020/165/examples/Date_class$
```

Our updated UML class **interaction diagram**:



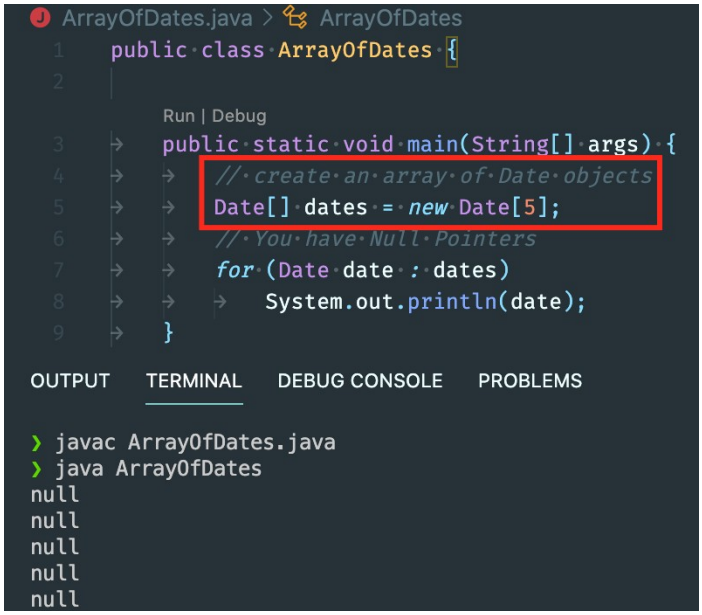
Additions to this class will be left as an exercise. Think about useful features that could be added.

- Different date formats: long, short
- Months as Strings
- Ordering two dates
- Compute the difference between two dates in months, weeks, days
- Add days to a date
- Add two dates together.
- Determine the day of the week
- Is the year a leap year?

Arrays of User Defined Objects

This small program demonstrates how you can create arrays of your own classes. A class defines a ***new data type,*** and these types can be used as any other type in Java.

As you have seen, when you first create an array of object types you have a collection of null references. The memory has been set aside for the ***reference*** but there is not yet a valid object for the reference to point to.



Fill the Array with Objects

To assign valid objects to the collection of Date references you need to call the Date constructor for each slot in the array. The concept is the same as using a single reference variable, we are not just dealing with an ***indexed collection*** of reference variables.

```
// populate the array with valid Date objects
dates[0] = new Date(1, 2, 2020);
dates[1] = new Date(1, 3, 2020);
dates[2] = new Date(1, 4, 2020);
dates[3] = new Date(1, 5, 2020);
dates[4] = new Date(1, 6, 2020);
```

```
Run | Debug
    public static void main(String[] args) {
        // create an array of Date objects
        Date[] dates = new Date[5];
        // You have Null Pointers
        for (Date date : dates)
            System.out.println(date);

        // populate the array with valid Date objects
        dates[0] = new Date(1, 2, 2020);
        dates[1] = new Date(1, 3, 2020);
        dates[2] = new Date(1, 4, 2020);
        dates[3] = new Date(1, 5, 2020);
        dates[4] = new Date(1, 6, 2020);
        // now you have actual date objects
        for (Date date : dates)
            System.out.println(date);
    }
}
```

OUTPUT TERMINAL DEBUG CONSOLE PROBLEMS

```
❯ javac ArrayOfDates.java
❯ java ArrayOfDates
null
null
null
null
null
1/2/2020
1/3/2020
1/4/2020
1/5/2020
1/6/2020
```

Build January

```
20      //·let's·build·January
21      Date[]·january·=·new·Date[31];
22      for·(int·day·=·0;·day·<·january.length;·++day)
23          january[day]·=·new·Date(1,·day·+·1,·2021);
24
25      System.out.println("\nJANUARY");
26      for·(Date·day·:·january)
27          System.out.println(day);
```

OUTPUT TERMINAL DEBUG CONSOLE PROBLEMS

```
JANUARY
1/1/2021
1/2/2021
1/3/2021
1/4/2021
1/5/2021
1/6/2021
1/7/2021
1/8/2021
1/9/2021
1/10/2021
1/11/2021
1/12/2021
1/13/2021
1/14/2021
1/15/2021
1/16/2021
1/17/2021
1/18/2021
1/19/2021
```

Change Month to March

```
20          //·let's·build·January
21          Date[]·january·=·new·Date[31];
22          for·(int·day·=·0;·day·<·january.length;·++day)
23              january[day]·=·new·Date(1,·day·+·1,·2021);
24
25          System.out.println("\nJANUARY");
26          for·(Date·day·:·january)
27              System.out.println(day);
28
29          //·change·the·month·to·March
30          for·(int·day·=·0;·day·<·january.length;·++day)
31              january[day].setMonth(3);
32
33          System.out.println("\nMARCH");
34          for·(Date·day·:·january)
35              System.out.println(day);
36      }
```

OUTPUT TERMINAL DEBUG CONSOLE PROBLEMS

```
MARCH
3/1/2021
3/2/2021
3/3/2021
3/4/2021
3/5/2021
3/6/2021
3/7/2021
3/8/2021
3/9/2021
3/10/2021
3/11/2021
3/12/2021
3/13/2021
3/14/2021
3/15/2021
3/16/2021
3/17/2021
3/18/2021
3/19/2021
3/20/2021
3/21/2021
3/22/2021
3/23/2021
3/24/2021
3/25/2021
3/26/2021
```