



# Chapter 8

## Classes and Objects: A Deeper Look ( I )

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# Objectives

- ▶ A deeper look at designing class
  - Access control
  - Data validation
  - Data encapsulation / Data hiding
  
- ▶ Composition
  
- ▶ Static members vs. instance members of a class

# A Time Class

```
public class Time1 {
```

```
    private int hour; // 0 - 23  
    private int minute; // 0 - 59  
    private int second; // 0 - 59
```

→ private instance variables

```
    // set a new time value using universal time  
    public void setTime(int h, int m, int s) { // ...  
    }  
  
    // convert to String in universal-time format (HH:MM:SS)  
    public String toUniversalString() { // ...  
    }  
  
    // convert to String in standard-time format (H:MM:SS AM or PM)  
    public String toString() { // ...  
    }
```

```
}
```

→ public instance methods (public services/ interfaces the class provides to its clients)

# Method Details

```
public class Time1 {  
    // set a new time value using universal time  
    public void setTime(int h, int m, int s) {  
        hour = ( ( h >= 0 && h < 24 ) ? h : 0 ); // validate hour  
        minute = ( ( m >= 0 && m < 60 ) ? m : 0 ); // validate minute  
        second = ( ( s >= 0 && s < 60 ) ? s : 0 ); // validate second  
    }  
}
```

# Method Details Cont.

```
public class Time1 {  
    // convert to String in universal-time format (HH:MM:SS)  
    public String toUniversalString() {  
        return String.format("%02d:%02d:%02d", hour, minute, second);  
    }  
  
    // convert to String in standard-time format (H:MM:SS AM or PM)  
    public String toString() {  
        return String.format("%d:%02d:%02d %s",  
            (hour == 0 || hour == 12) ? 12 : hour % 12,  
            minute, second, hour < 12 ? "AM" : "PM");  
    }  
}
```

# Default Constructor

- ▶ Class `Time1` does not declare a constructor
- ▶ It will have a default constructor supplied by the compiler
- ▶ `int` instance variables implicitly receive the default value `0`
- ▶ Instance variables also can be initialized when they are declared in the class body, using the same initialization syntax as with a local variable

```
public class Time1 {  
    private int hour = 19; //default constructor will not initialize hour  
    private int minute = 1; //default constructor will not initialize minute  
    private int second; //default constructor will initialize second to 0  
}
```



# Using the Time Class

```
public class Time1Test {  
    public static void main(String[] args) {  
        Time1 time = new Time1(); // invoke default constructor  
        System.out.print("Universal time: ");  
        System.out.println(time.toUniversalString());  
        System.out.print("Standard time: ");  
        System.out.println(time.toString());  
    }  
}
```

Universal time: 19:01:00

Standard time: 7:01:00 PM



# Using the Time Class

```
public class Time1Test {  
    public static void main(String[] args) {  
        Time1 time = new Time1();  
        time.setTime(13, 27, 6);  
        System.out.print("Universal time: ");  
        System.out.println(time.toUniversalString());  
        System.out.print("Standard time: ");  
        System.out.println(time.toString());  
    }  
}
```

Use object reference to  
invoke an instance method

Universal time: 13:27:06  
Standard time: 1:27:06 PM



# Using the Time Class

```
public class Time1Test {  
    public static void main(String[] args) {  
        Time1 time = new Time1();  
  
        time.setTime(99, 99, 99);  
  
        System.out.print("Universal time: ");  
        System.out.println(time.toUniversalString());  
        System.out.print("Standard time: ");  
        System.out.println(time.toString());  
    }  
}
```

Universal time: 00:00:00

Standard time: 12:00:00 AM

# Valid Value vs. Correct Value

- ▶ A **valid value** for `minute` must be in the range 0 to 59.
- ▶ A **correct value** for `minute` in a particular application would be the actual minute at that time of the day.
  - If the actual time is 17 minutes and you accidentally set the time to 19 minutes, the 19 is a *valid* value (0 to 59) but not a *correct value*.
  - If you set the time to 17 minutes after the hour, then 17 is a correct value—and a **correct value is *always* a valid value**.

# Handling Invalid Values – Design 1

- ▶ Current setTime sets the corresponding instance variables to zeros when receiving invalid values.

```
// set a new time value using universal time
public void setTime(int h, int m, int s) {
    hour = ( ( h >= 0 && h < 24 ) ? h : 0 ); // validate hour
    minute = ( ( m >= 0 && m < 60 ) ? m : 0 ); // validate minute
    second = ( ( s >= 0 && s < 60 ) ? s : 0 ); // validate second
}
```

While 0 is certainly a valid value, it is unlikely to be correct. Is there an alternative approach?



# Handling Invalid Values – Design 2

- ▶ When receiving invalid values, we could also simply leave the object in its current state, without changing the instance variable.
  - Time objects begin in a valid state and setTime method **rejects (do nothing about)** any invalid values.
  - Some designers feel this is better than setting instance variables to zeros.

```
// set a new time value using universal time
public void setTime(int h, int m, int s) {
    if(h >= 0 && h < 24) hour = h; // reject invalid values
    if(m >= 0 && m < 60) minute = m;
    if(s >= 0 && s < 60) second = s;
}
```

# Handling Invalid Values

- ▶ Designs discussed so far do not inform the client code of invalid values (**no return to callers**)

// approach 1: setting to zeros

```
public void setTime(int h, int m, int s) {  
    hour = ( ( h >= 0 && h < 24 ) ? h : 0 );  
    minute = ( ( m >= 0 && m < 60 ) ? m : 0 );  
    second = ( ( s >= 0 && s < 60 ) ? s : 0 );  
}
```

// approach 2: keeping the last object state

```
public void setTime(int h, int m, int s) {  
    if(h >= 0 && h < 24) hour = h;  
    if(m >= 0 && m < 60) minute = m;  
    if(s >= 0 && s < 60) second = s;  
}
```

# Handling Invalid Values – Design 3

- ▶ `setTime` could return a value such as `true` if all the values are valid and `false` if any of the values are invalid.
- ▶ The caller would check the return value, and if it is `false`, would attempt to set the time again.

```
public boolean setTime(int h, int m, int s) {...}
```

# this Reference

```
public class Time1 {  
    private int hour; // 0 - 23  
    private int minute; // 0 - 59  
    private int second; // 0 - 59  
  
    // set a new time value using universal time  
    public void setTime(int hour, int minute, int second) {  
        if(hour >= 0 && hour < 24) this.hour = hour;  
        if(minute >= 0 && minute < 60) this.minute = minute;  
        if(second >= 0 && second < 60) this.second = second;  
    }  
}
```

The use of `this` is to differentiate the formal parameters of methods and the data members of classes with the same name.

# this Reference

```
public class Time1 {  
    private int hour; // 0 - 23  
    private int minute; // 0 - 59  
    private int second; // 0 - 59  
  
    // set a new time value using universal time  
    public void setTime(int hour, int minute, int second) {  
        if(hour >= 0 && hour < 24) this.hour = hour;  
        if(minute >= 0 && minute < 60) this.minute = minute;  
        if(second >= 0 && second < 60) this.second = second;  
    }  
}
```

**Shadowing:** using variables in overlapping scopes with the same name where the variable in low-level scope overrides the variable of high-level scope.

If a method contains a local variable (including parameters) with the same name as an instance variable, the **local variable shadows the instance variable** in the method's scope



# this Reference

```
public class Time1 {  
    // convert to String in universal-time format (HH:MM:SS)  
    public String toUniversalString() {  
        return String.format("%02d:%02d:%02d", hour, minute, second);  
    }  
    public String buildString() {  
        return "Universal format: " + this.toUniversalString();  
    }  
}
```



**Q:** Do we need this reference here?

**A:** this is not required to call other methods of the same class.

# Constructors

```
public class Time2 {  
    private int hour;  
    private int minute;  
    private int second;  
  
    public void setTime(int h, int m, int s) {  
        setHour(h);  
        setMinute(m);  
        setSecond(s);  
    }  
  
    public void setHour(int h) {  
        hour = ( ( h >= 0 && h < 24 ) ? h : 0 );  
    }  
  
    public void setMinute(int m) {  
        minute = ( ( m >= 0 && m < 60 ) ? m : 0 );  
    }  
  
    public void setSecond(int s) {  
        second = ( ( s >= 0 && s < 60 ) ? s : 0 );  
    }  
}
```

Setter methods for  
manipulating the fields

# Constructors (cont.)

```
public int getHour() {  
    return hour;  
}  
  
public int getMinute() {  
    return minute;  
}  
  
public int getSecond() {  
    return second;  
}
```

Getter methods for retrieving  
the value of the fields

```
public String toUniversalString() {  
    return String.format("%02d:%02d:%02d",  
        getHour(), getMinute(), getSecond());  
}  
  
public String toString() {  
    return String.format("%d:%02d:%02d %s",  
        ( (getHour() == 0 || getHour() == 12) ? 12 : getHour() % 12 ),  
        getMinute(), getSecond(), (getHour() < 12 ? "AM" : "PM") );  
}  
}
```

# Overloaded Constructors

```
public class Time2 {  
    public Time2(int h, int m, int s) {  
        setTime(h, m, s);  
    }  
    public Time2(int h, int m) {  
        this(h, m, 0);  
    }  
    public Time2(int h) {  
        this(h, 0, 0);  
    }  
    public Time2() {  
        this(0, 0, 0);  
    }  
    public Time2(Time2 time) {  
        this(time.getHour(), time.getMinute(), time.getSecond());  
    }  
}
```

Invoke setTime to validate data for object construction

Invoke three-argument constructor, hour and minute values supplied

Using this in method-call syntax invokes another constructor of the same class. This helps reuse initialization code.

# Overloaded Constructors

```
public class Time2 {  
    public Time2(int h, int m, int s) {  
        setTime(h, m, s);  
    }  
    public Time2(int h, int m) {  
        this(h, m, 0);  
    }  
    public Time2(int h) {  
        this(h, 0, 0);  
    }  
    public Time2() {  
        this(0, 0, 0);  
    }  
    public Time2(Time2 time) {  
        this(time.getHour(), time.getMinute(), time.getSecond());  
    }  
}
```

Invoke three-argument constructor, hour value supplied

No-argument constructor, invokes three-argument constructor to initialize all values to 0

Another object supplied, invoke three-argument constructor for initialization

# Overloaded Constructors

```
public class Time2 {  
    public Time2(int h, int m, int s) {  
        setTime(h, m, s);  
    }  
    public Time2(int h, int m) {  
        this(h, m, 0);  
    }  
    public Time2(int h) {  
        this(h, 0, 0);  
    }  
    public Time2() {  
        this(0, 0, 0);  
    }  
    public Time2(Time2 time) {  
        this(time.getHour(), time.getMinute(), time.getSecond());  
    }  
}
```

- 'this()' can only be called in constructors
- Call to 'this()' must be first statement in constructor body

# Using Overloaded Constructors

```
public class Time2Test {  
    public static void main(String[] args) {  
        Time2 t1 = new Time2();  
        Time2 t2 = new Time2(2);  
        Time2 t3 = new Time2(21, 34);  
        Time2 t4 = new Time2(12, 25, 42);  
        Time2 t5 = new Time2(27, 74, 99);  
        Time2 t6 = new Time2(t4);  
  
        System.out.println(t1.toUniversalString());  
        System.out.println(t2.toUniversalString());  
        System.out.println(t3.toUniversalString());  
        System.out.println(t4.toUniversalString());  
        System.out.println(t5.toUniversalString());  
        System.out.println(t6.toUniversalString());  
    }  
}
```

Compiler determines which constructor to call based on the number and types of the arguments

00:00:00

02:00:00

21:34:00

12:25:42

00:00:00

12:25:42



# Data Encapsulation (数据封装)

- ▶ Classes often provide `public` methods to allow clients to *set* (i.e., assign values to) or *get* (i.e., obtain the values of) `private` instance variables.
- ▶ We use `private` to **protect** data fields, and use `public` methods to **control** the access to the data





## Data Encapsulation Benefit 1: Control Access

```
public class Time {  
    private int hour;  
  
    public void setHour(int h) {  
        // validity check  
        if(h >= 0 && h < 24 ){  
            hour = h;  
        }  
    }  
  
    public int getHour() {  
        // user permission check  
        if(userHasPermission()){  
            return hour;  
        }  
        return -1;  
    }  
}
```

```
public class TimeTest {  
    public static void main(String[] args) {  
        Time time = new Time();  
        time.hour = -1;    compilation error  
        time.setHour(-1); access control  
        time.getHour();    access control  
    }  
}
```

## Data Encapsulation Benefit 2: Minimize the Impact of Changing Data

- ▶ Someday, we may want to alter the data fields
- ▶ We may use only one `int` variable (**4 bytes of memory**) to store the number of seconds elapsed since midnight rather than three `int` variables (**12 bytes of memory**)

```
public class Time3 {  
    private int hour;  
    private int minute;  
    private int second;  
  
    public String toUniversalString() {  
        return String.format("%02d:%02d:%02d",  
                               hour, minute, second);  
    }  
}
```

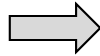


```
public class Time3 {  
    private int elapsed_seconds;  
  
    public String toUniversalString() {  
        return String.format("%02d:%02d:%02d",  
                               hour, minute, second);  
    }  
}
```

No longer work!

# Data Encapsulation Benefit 2: Minimize the Impact of Changing Data

```
public class Time3 {  
    private int hour;  
    private int minute;  
    private int second;  
  
    public int getHour() {  
        return hour;  
    }  
  
    public int getMinute() {  
        return minute;  
    }  
  
    public int getSecond() {  
        return second;  
    }  
  
    public String toUniversalString() {  
        return String.format("%02d:%02d:%02d",  
            getHour(), getMinute(), getSecond());  
    }  
}
```



```
public class Time3 {  
  
    private int elapsed_seconds;  
  
    public int getHour() {  
        return elapsed_seconds / 3600;  
    }  
  
    public int getMinute() {  
        return (elapsed_seconds % 3600) / 60;  
    }  
  
    public int getSecond() {  
        return elapsed_seconds % 60;  
    }  
  
    public String toUniversalString() {  
        return String.format("%02d:%02d:%02d",  
            getHour(), getMinute(), getSecond());  
    }  
}
```

**Still work!**

# Design Guide

- ▶ Declare class data fields private.
  - To prevent data from being tampered with
  - To make the class easy to maintain (**hide the implementation details**), i.e., we can change the underlying implementation of data fields **without breaking client code**
  
- ▶ Declare methods public.
  - We have control over how fields are accessed and modified
  - Clients can use public methods without worrying about internal details



# Objectives

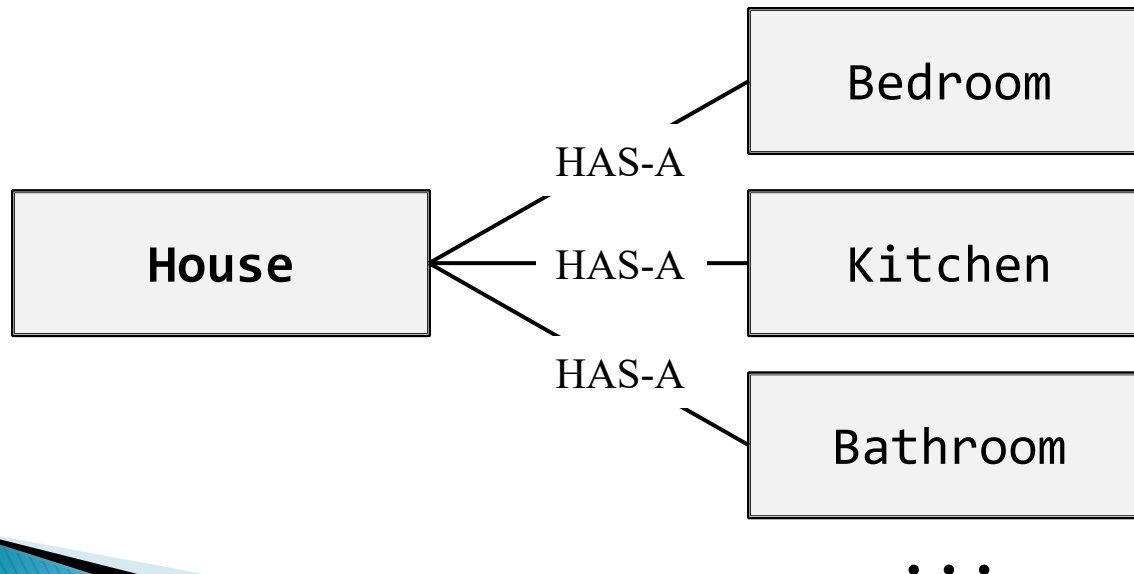
- ▶ A deeper look at designing class
  - Access control
  - Data validation
  - Data encapsulation / Data hiding
- ▶ Composition
- ▶ Static members vs. instance members of a class

# Code Reuse

- ▶ The essence of code reuse is that you don't need to rewrite the code
- ▶ In OOP, code reuse means that new classes (types) are built on the basis of already existing classes (types).
  - **Composition (组合)**: a class contains an object of another class. This approach uses the functionality of the finished code;
  - **Inheritance (继承)**: Later

# Composition

- ▶ A class can have references to objects of other classes as members.
- ▶ This is called **composition** and is sometimes referred to as a **has-a relationship**.



# Designing an Employee Class

- ▶ Suppose we are designing an Employee Management System, what information should be included in the Employee class?

First name (String type)

Date of birth (? type)

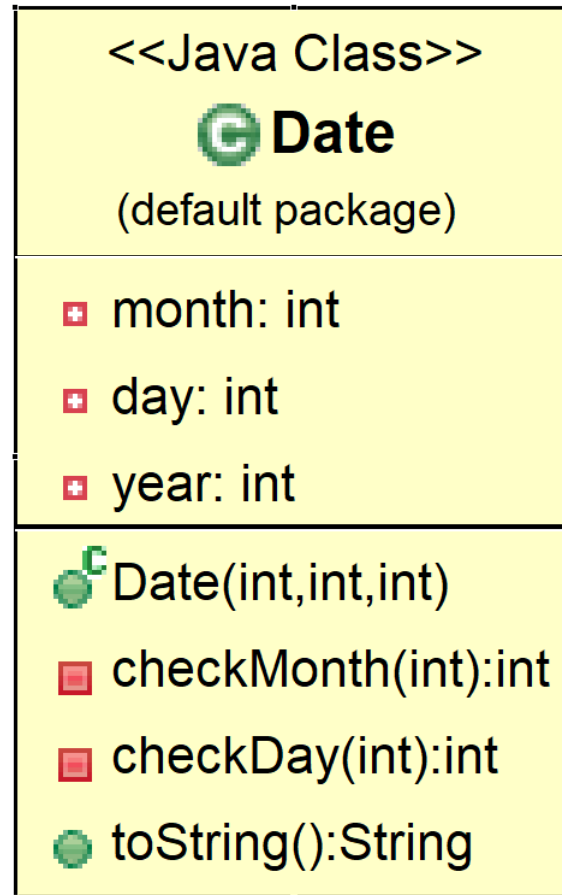
Last name (String type)

Date of hiring (? type)

... potentially lots of other information




# Define the Date Class



# Define the Employee class


<<Java Class>>


 **Employee**

(default package)

- firstName: String
- lastName: String
- birthDate: Date
- hireDate: Date

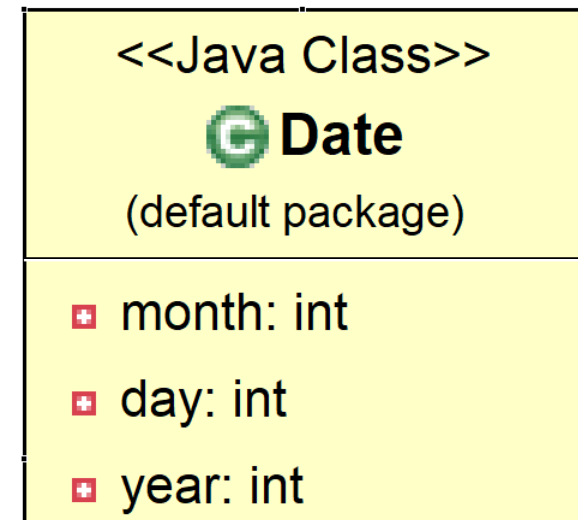
References to objects of **String** and **Date** classes as members (**composition**)

 Employee(String,String,Date,Date)

 toString():String

# Let's Look at the Real Code



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



We make the instance variables private for data hiding.

# Let's Look at the Real Code

```
public Date(int theMonth, int theDay, int theYear) {  
    month = checkMonth(theMonth);  
    year = theYear;  
    day = checkDay(theDay);  
    System.out.printf("Date object constructor for date %s\n", this);  
}
```

 Date(int,int,int)  
 checkMonth(int):int

Constructor performs data validation

```
private int checkMonth(int testMonth) {  
    if(testMonth > 0 && testMonth <=12) return testMonth;  
    else {  
        System.out.printf("Invalid month (%d), set to 1", testMonth);  
        return 1;  
    }  
}
```

Data validation is used internally in the class, not intended to be used by the public, hence the “private” keyword

# Let's Look at the Real Code

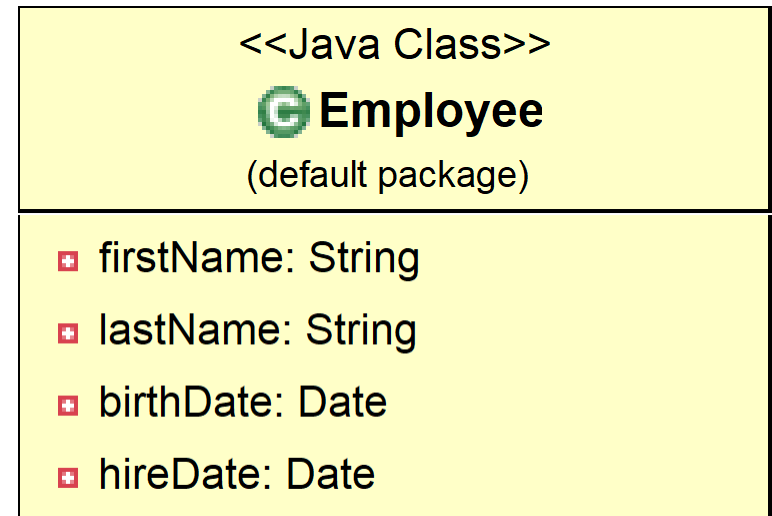
```
private int checkDay(int testDay) { // data validation
    int[] daysPerMonth =
        { 0, 31, 28, 31, 30, 31, 30, 31, 31, 30, 31, 30, 31 };
    if(testDay > 0 && testDay <= daysPerMonth[month]) return testDay;
    if(month == 2 && testDay == 29 && (year % 400 == 0 ||
        (year % 4 == 0 && year % 100 != 0)))
        return testDay;
    System.out.printf("Invalid day (%d), set to 1", testDay);
    return 1;
}

public String toString() { // transform object to String representation
    return String.format("%d/%d/%d", month, day, year);
}
```

■ checkDay(int):int  
● toString():String

# Let's Look at the Real Code

```
public class Employee {  
    private String firstName;  
    private String lastName;  
    private Date birthDate;  
    private Date hireDate;  
}
```



Again, we make the instance variables private for data hiding.

# Let's Look at the Real Code

```
public Employee(String first, String last, Date dateOfBirth,
                Date dateOfHire) { // constructor
    firstName = first;
    lastName = last;
    birthDate = dateOfBirth;
    hireDate = dateOfHire;
}
```

```
Employee(String,String,Date,Date)
toString():String
```

```
public String toString() { // to String representation
    return String.format("%s, %s Hired: %s Birthday: %s",
        lastName, firstName, hireDate, birthDate);
}
```

# Let's Run the Code

```
public class EmployeeTest {  
    public static void main(String[] args) {  
        Date birth = new Date(7, 24, 1949);  
        Date hire = new Date(3, 12, 1988);  
        Employee employee = new Employee("Bob", "Blue", birth, hire);  
        System.out.println(employee);  
    }  
}
```

```
Date object constructor for date 7/24/1949  
Date object constructor for date 3/12/1988  
Blue, Bob Hired: 3/12/1988 Birthday: 7/24/1949
```





# Objectives

- ▶ A deeper look at designing class
  - Access control
  - Data validation
  - Data encapsulation / Data hiding
- ▶ Composition
- ▶ Static members vs. instance members of a class


# static Class Members

- ▶ A **static** variable represents **class-wide information**. All objects of the class share the same piece of data.

```
public class Employee {
```

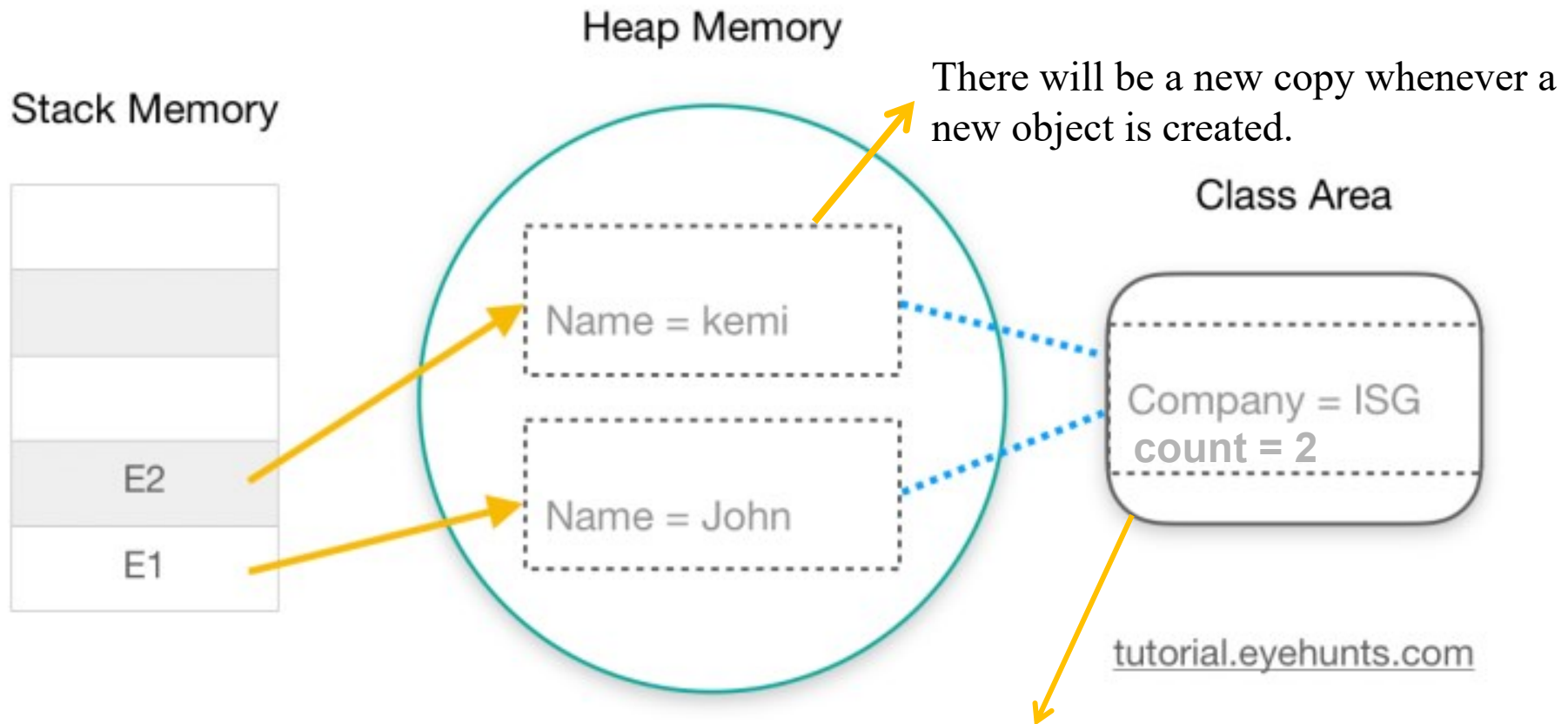
```
    private String name;
```

There will be a new copy  
whenever a new object is created.

```
 private static int count; // number of employees created  
}
```




There is only one copy for each static variable. Make a variable **static** when all objects of the class must use the same copy of the variable.

# static Class Members



There is only one copy for each static variable. Make a variable **static** when all objects of the class must use the same copy of the variable.

# Example

```
public class Employee {  
    private String firstName;  
    private String lastName;  
     private static int count; // number of employees created  
    public Employee(String first, String last) {  
        firstName = first;  
        lastName = last;  
         ++count;  
        System.out.printf("Employee constructor: %s %s; count = %d\n",  
                           firstName, lastName, count);  
    }  
    public String getFirstName() { return firstName; }  
    public String getLastName() { return lastName; }  
     public static int getCount() { return count; }  
}
```



# Example

```
public class EmployeeTest {  
    public static void main(String[] args) {  
        System.out.printf("Employees before instantiation: %d\n",  
                           Employee.getCount());  
        Employee e1 = new Employee("Bob", "Blue");  
        Employee e2 = new Employee("Susan", "Baker");  
        System.out.println("\nEmployees after instantiation:");  
        System.out.printf("via e1.getCount(): %d\n", e1.getCount());  
        System.out.printf("via e2.getCount(): %d\n", e2.getCount());  
        System.out.printf("via Employee.getCount(): %d\n", Employee.getCount());  
        System.out.printf("\nEmployee 1: %s %s\nEmployee 2: %s %s\n",  
                           e1.getFirstName(), e1.getLastName(),  
                           e2.getFirstName(), e2.getLastName());  
    }  
}
```

The only way to  
access private static  
variables at this stage

More choices when  
there are objects

# Example

```
Employees before instantiation: 0  
Employee constructor: Bob Blue; count = 1  
Employee constructor: Susan Baker; count = 2
```

```
Employees after instantiation:  
via e1.getCount(): 2  
via e2.getCount(): 2  
via Employee.getCount(): 2
```


} **Access the same variable**

```
Employee 1: Bob Blue  
Employee 2: Susan Baker
```

# static Class Members

- ▶ getCount() is a **static** method
- ▶ getCount() accesses a static variable **count**

```
public class Employee {  
    private String name;  
    private static int count; // number of employees created  
    public static int getCount() { return count; }  
}
```



Can getCount() access the instance variable **name**?

Can we make getCount() an instance method?

```
public class Employee {
```

```
    private static int count;  
    private String name;
```

```
    public static void m1(){  
        count++;  
        m3();  
  
        System.out.println(name);  
        m4();  
    }
```

```
    public void m2(){  
        count++;  
        m3();  
  
        System.out.println(name);  
        m4();  
    }
```

```
    public static void m3(){}  
  
    public void m4(){}  
}
```

- `count` is static/class variable
- `name` is instance variable



### Static method `m1`

- can access static variable `count` and static method `m3`
- **CANNOT** access instance variable `name` and instance method `m4`

- ▶ A static method CANNOT access non-static class members (instance variables, instance methods), because a static method can be called even when no objects of the class have been instantiated.
- ▶ For the same reason, the `this` reference cannot be used in a static method.



```
public class Employee {
```

```
    private static int count;  
    private String name;
```

```
    public static void m1(){  
        count++;  
        m3();  
  
        System.out.println(name);  
        m4();  
    }
```

```
    public void m2(){  
        count++;  
        m3();  
  
        System.out.println(name);  
        m4();  
    }
```

```
    public static void m3(){}  
  
    public void m4(){}  
}
```

- `count` is static/class variable
- `name` is instance variable



## Instance method `m2`

- can access static variable `count` and static method `m3`
- can access instance variable `name` and instance method `m4`

```
public class Employee {  
    private static int count;  
    private String name;
```

```
    public static int getCount() {  
        return count;  
    }
```

```
    public static void main(String[] args) {
```



```
        System.out.println(count);
```

```
        System.out.println(name);
```

```
        Employee e = new Employee();
```

```
        System.out.println(e.name);
```

```
        System.out.println(e.count);
```

```
        System.out.println(e.getCount());
```

```
        System.out.println(Employee.count);
```

```
        System.out.println(Employee.getCount());
```

```
    }
```

**main(String[] args) is  
also a static method**

OK.


- main() can access **private** count for being inside the same class
- main() can access **static** count as it's a static method itself
- count is not initialized explicitly, the compiler assigns it a default value (e.g., 0 for int)


```
public class Employee {  
    private static int count;  
    private String name;
```

```
    public static int getCount() {  
        return count;  
    }
```

```
    public static void main(String[] args) {
```

```
        System.out.println(count);
```

 `System.out.println(name);`

 `Employee e = new Employee();`  
`System.out.println(e.name);`

```
System.out.println(e.count);  
System.out.println(e.getCount());
```

```
System.out.println(Employee.count);  
System.out.println(Employee.getCount());
```

```
}
```

**main(String[] args) is  
also a static method**

NO. A static method CANNOT  
access an instance variable.

We need to create an instance first  
before accessing `name`.

```
public class Employee {  
    private static int count;  
    private String name;
```

```
    public static int getCount() {  
        return count;  
    }
```



```
    public static void main(String[] args) {
```

```
        System.out.println(count);
```

```
        System.out.println(name);
```

```
        Employee e = new Employee();
```

```
        System.out.println(e.name);
```

```
 System.out.println(e.count);  
 System.out.println(e.getCount());
```

```
        System.out.println(Employee.count);
```

```
        System.out.println(Employee.getCount());
```

```
    }
```

**main(String[] args) is  
also a static method**

OK. A class's static member  
can be accessed through a  
reference to any object of the class.  
But this is **NOT recommended**.

```
public class Employee {  
    private static int count;  
    private String name;
```

```
  
    public static int getCount() {  
        return count;  
    }
```

```
  
    public static void main(String[] args) {
```

```
        System.out.println(count);
```

```
  
        System.out.println(name);
```

```
  
        Employee e = new Employee();
```

```
        System.out.println(e.name);
```

```
  
        System.out.println(e.count);
```

```
        System.out.println(e.getCount());
```

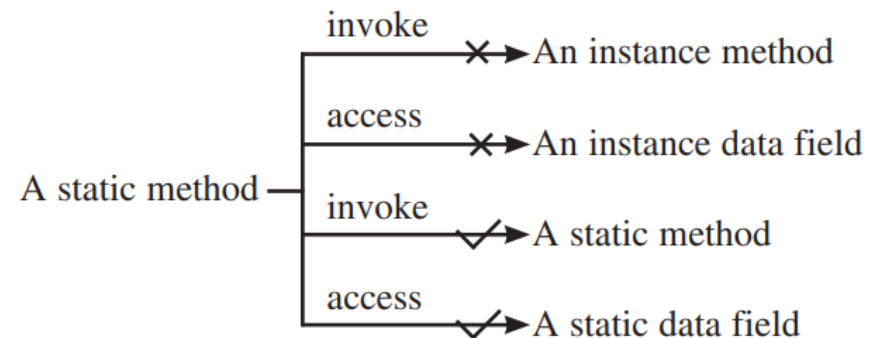
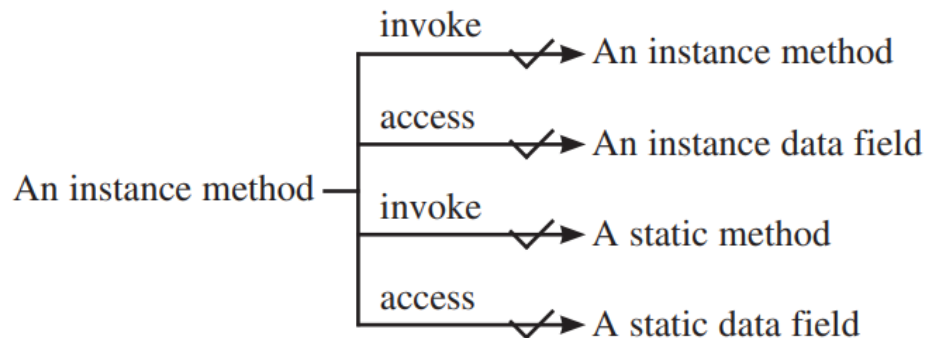
```
  
        System.out.println(Employee.count);
```

```
        System.out.println(Employee.getCount());
```

**main(String[] args) is  
also a static method**

OK and **recommended**. A class's **static** member can be accessed by qualifying the member name with the class name and a dot (**.**), e.g., **Math.PI**

# static Methods vs instance Methods





# static members in Class Math

- ▶ Fields and methods in class `Math` are `public` and `static`
  - `public` allows you to use these fields anywhere in your own classes
  - `static` makes them accessible via the class name `Math` and a dot (`.`) separator
- ▶ Class `Math` declares commonly used mathematical constants
  - `Math.PI` (3.141592653589793)
  - `Math.E` (2.718281828459045) is the base value for natural logarithms



## Many more useful static methods in `java.lang.Math` class:

Method	Description	Example
<code>abs( x )</code>	absolute value of $x$	<code>abs( 23.7 )</code> is 23.7 <code>abs( 0.0 )</code> is 0.0 <code>abs( -23.7 )</code> is 23.7
<code>ceil( x )</code>	rounds $x$ to the smallest integer not less than $x$	<code>ceil( 9.2 )</code> is 10.0 <code>ceil( -9.8 )</code> is -9.0
<code>cos( x )</code>	trigonometric cosine of $x$ ( $x$ in radians)	<code>cos( 0.0 )</code> is 1.0
<code>exp( x )</code>	exponential method $e^x$	<code>exp( 1.0 )</code> is 2.71828 <code>exp( 2.0 )</code> is 7.38906
<code>floor( x )</code>	rounds $x$ to the largest integer not greater than $x$	<code>floor( 9.2 )</code> is 9.0 <code>floor( -9.8 )</code> is -10.0
<code>log( x )</code>	natural logarithm of $x$ (base $e$ )	<code>log( Math.E )</code> is 1.0 <code>log( Math.E * Math.E )</code> is 2.0
<code>max( x, y )</code>	larger value of $x$ and $y$	<code>max( 2.3, 12.7 )</code> is 12.7 <code>max( -2.3, -12.7 )</code> is -2.3
<code>min( x, y )</code>	smaller value of $x$ and $y$	<code>min( 2.3, 12.7 )</code> is 2.3 <code>min( -2.3, -12.7 )</code> is -12.7
<code>pow( x, y )</code>	$x$ raised to the power $y$ (i.e., $x^y$ )	<code>pow( 2.0, 7.0 )</code> is 128.0 <code>pow( 9.0, 0.5 )</code> is 3.0
<code>sin( x )</code>	trigonometric sine of $x$ ( $x$ in radians)	<code>sin( 0.0 )</code> is 0.0
<code>sqrt( x )</code>	square root of $x$	<code>sqrt( 900.0 )</code> is 30.0
<code>tan( x )</code>	trigonometric tangent of $x$ ( $x$ in radians)	<code>tan( 0.0 )</code> is 0.0





# Static Method `valueOf` in `String`

- ▶ Every object in Java has a `toString` method that enables a program to obtain the object's `String` representation.
- ▶ Unfortunately, this technique cannot be used with primitive types because they do not have methods.
- ▶ Class `String` provides `static` methods (associated with class, no need to create objects for their invocation) that take an argument of any type and convert it to a `String` object.

```
static String valueOf(boolean b)
```

```
static String valueOf(char c)
```

```
static String valueOf(char[] data)
```

```
static String valueOf(char[] data, int offset, int count)
```

```
static String valueOf(double d)
```

```
static String valueOf(float f)
```

```
static String valueOf(int i)
```

```
static String valueOf(long l)
```

```
boolean booleanValue = true;
char charValue = 'Z';
int intValue = 7;
long longValue = 10000000000L;
float floatValue = 2.5f;
double doubleValue = 33.3333; // no f suffix, double is default
char[] charArray = {'a', 'b', 'c', 'd', 'e', 'f'};
System.out.println(String.valueOf(booleanValue));
System.out.println(String.valueOf(charValue));
System.out.println(String.valueOf(intValue));
System.out.println(String.valueOf(longValue));
System.out.println(String.valueOf(floatValue));
System.out.println(String.valueOf(doubleValue));
System.out.println(String.valueOf(charArray));
```

true

Z

7

10000000000

2.5

33.3333

abcdef