# CSE 143X

## Accelerated Computer Programming I/II

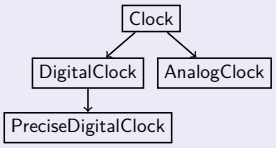


# Inheritance & Polymorphism


## Today's Goals



### Time!




Our goals are to understand how **methods get inherited** and how **`Objects` in a hierarchy interact**.

- `Clock c = new DigitalClock(true);`
- `AnalogClock ac = new DigitalClock(true);`
- `PreciseDigitalClock pdc = new DigitalClock(true);`
- `c.getTime(); ac.getTime(); pdc.getTime();`

## `Clock`



### `Clock` Class

```
1  public class Clock {
2     private int hour;
3     private int minute;
4
5     public int getMinute() { return this.minute; }
6     public int getHour() { return this.hour; }
7     public String getTime() { return hour + " " + minute; }
8  }
```

OUTPUT

```
>> Clock c = new Clock(); // hour = 4, minute = 12
>> System.out.println(c.getTime() + "..." + c.getHour() + "..." + c.getMinute());
>> 4 12...4...12
```

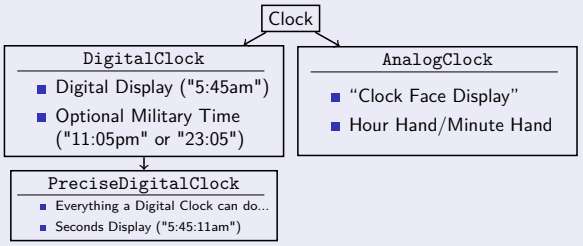
### What specializations could we make to `Clock`?

- An "analog" clock with a face?
- A "digital" clock with military time?
- A clock with seconds?

## `Clock` Hierarchy



### `Clock` Hierarchy Diagram




For each of the following, is it **always**, **sometimes**, or **never** true:

- A `DigitalClock` is a `Clock`?
  **Always!** A `DigitalClock` is a type of `Clock` with digital features.
- An `AnalogClock` is a `DigitalClock`?
  **Never!** `AnalogClock`'s have a face; `DigitalClock`'s don't.
- A `PreciseDigitalClock` is a `DigitalClock`?
  **Always!** A `PreciseDigitalClock` is a `DigitalClock` that includes seconds.
- A `DigitalClock` is a `PreciseDigitalClock`?
  **Sometimes!** Not all `DigitalClocks` have seconds, but those that do are `PreciseDigitalClocks`.
- A `Clock` is a `DigitalClock`?
  **Sometimes!** Not all `Clocks` have `DigitalClock` features, but those that do are `DigitalClocks`.

## `AnalogClock` Class



### Class

```
1  public class AnalogClock extends Clock {
2     public static final int NUM_HOURS = 12;
3     public static final int NUM_MINUTES = 60;
4
5     public double getHourHandAngle() {
6        return 360 * ((double) (this.getHour() % 12) / NUM_HOURS);
7     }
8
9     public double getMinuteHandAngle() {
10       return 360 * ((double) this.getMinute() / NUM_MINUTES);
11    }
12
13    public String getTime() {
14       return "Hour Hand: " + this.getHourHandAngle() + "%, "
15             + "Minute Hand: " + this.getMinuteHandAngle() + "%";
16    }
17 }
```

### `AnalogClock` vs. `Clock`

- Is an `AnalogClock` a `Clock`?
  **Always!** An `AnalogClock` is a `Clock` with extra features.
- What is different about an `AnalogClock`?
  - It has new methods: `getHourHandAngle`, `getMinuteHandAngle`
  - It "overrides" `getTime` to do something different

## AnalogClock Methods 5

### Class

```
public class AnalogClock extends Clock {
   public static final int NUM_HOURS = 12;
   public static final int NUM_MINUTES = 60;

   public double getHourHandAngle() {
      return 360 * ((double) (this.getHour() % 12) / NUM_HOURS);
   }

   public double getMinuteHandAngle() {
      return 360 * ((double) this.getMinute() / NUM_MINUTES);
   }

   public String getTime() {
      return "Hour Hand: " + this.getHourHandAngle() + "%, "
            + "Minute Hand: " + this.getMinuteHandAngle() + "%";
   }
}
```

### AnalogClock Puzzle #1

```
AnalogClock c1 = new AnalogClock();
System.out.println(c1.getTime());
System.out.println(c1.getHourHandAngle());
System.out.println(c1.getMinuteHandAngle());
```

OUTPUT

```
>> Hour Hand:    180%, MinuteHand: 60%
>> 180
>> 60
```

## AnalogClock Methods 6

### Class

```
public class AnalogClock extends Clock {
   public static final int NUM_HOURS = 12;
   public static final int NUM_MINUTES = 60;

   public double getHourHandAngle() {
      return 360 * ((double) (this.getHour() % 12) / NUM_HOURS);
   }

   public double getMinuteHandAngle() {
      return 360 * ((double) this.getMinute() / NUM_MINUTES);
   }

   public String getTime() {
      return "Hour Hand: " + this.getHourHandAngle() + "%, "
            + "Minute Hand: " + this.getMinuteHandAngle() + "%";
   }
}
```

### AnalogClock Puzzle #2

```
Clock c2 = new AnalogClock();
System.out.println(c2.getTime());
System.out.println(c2.getHourHandAngle());
System.out.println(c2.getMinuteHandAngle());
```

**This doesn't compile! Java treats `c2` like a `Clock`. The second and third calls don't make sense for a clock. If we remove the second and third lines, we get:**

OUTPUT

```
>> Hour Hand:    180%, MinuteHand: 60%
```

## More Clock Classes 7

```
public class DigitalClock extends Clock {
   private boolean usingMilitaryTime;

   public DigitalClock(boolean usingMilitaryTime) {
      this.usingMilitaryTime = usingMilitaryTime;
   }
   public boolean isMilitaryTime() { return usingMilitaryTime; }
   public int getHour() {
      if (this.isMilitaryTime() || super.getHour() <= 12) {
         return super.getHour();
      }
      else { return super.getHour() - 12; }
   }
   public String getPeriod() {
      if (this.isMilitaryTime()) { return ""; }
      else if (super.getHour() <= 12) { return "am"; }
      else { return "pm"; }
   }
   public String getTime() {
      return this.getHour() + ":" + this.getMinute() + this.getPeriod();
   }
}

public class PreciseDigitalClock extends DigitalClock {
   private int second;

   public PreciseDigitalClock() { super(false); }
   public int getSecond() { return this.second; }
   public String getTime() {
      return this.getHour() + ":" + this.getMinute() + ":" + this.getSecond()
            + this.getPeriod();
   }
}
```

## DigitalClock & PreciseDigitalClock 8

### Clock vs. DigitalClock vs. PreciseDigitalClock

- Is a DigitalClock a Clock?
  **Always!** A `DigitalClock` is a `Clock` with extra features.
- Is a PreciseDigitalClock a DigitalClock?
  **Always!** A `PreciseDigitalClock` is a `DigitalClock` with extra features.
- What is different about a DigitalClock (from a Clock)?
  - It has a new constructor
  - It has a new field: `usingMilitaryTime`
  - It has new methods: `getPeriod`, `isMilitaryTime`
  - It "overrides" `getTime` and `getHour` to do something different
- What is different about a PreciseDigitalClock (from a DigitalClock)?
  - It is missing **the one argument constructor**
  - It has a new field: `second`
  - It has a new method: `getSecond`
  - It "overrides" `getTime` to do something different

## DigitalClock Puzzles 9

### DigitalClock Puzzle #1

```
DigitalClock c3 = new DigitalClock(false); //hour = 13, minute = 22
System.out.println(c3.getTime());
System.out.println(c3.getHour());
System.out.println(c3.getMinute());
System.out.println(c3.getPeriod());
```

OUTPUT

```
>> 1:22pm
>> 1
>> 22
>> pm
```

### DigitalClock Puzzle #2

```
Clock c4 = new DigitalClock(false); //hour = 13, minute = 22
System.out.println(c4.getTime());
System.out.println(c4.getHour());
System.out.println(c4.getMinute());
System.out.println(c4.getPeriod());
```

**This doesn't compile. `Clock` doesn't have a `getPeriod` method!**

## DigitalClock Puzzles (Continued) 10

### DigitalClock Puzzle #3

```
Clock c4 = new DigitalClock(false); //hour = 13, minute = 22
System.out.println(c4.getTime());
System.out.println(c4.getHour());
System.out.println(c4.getMinute());
```

OUTPUT

```
>> 1:22pm
>> 1
>> 22
```

**Notice that Java knows that `c4` is actually a `DigitalClock`.**

### DigitalClock Puzzle #4

```
PreciseDigitalClock c5 = new PreciseDigitalClock(); //hour=13,minute=22,second=52
System.out.println(c5.getTime());
System.out.println(c5.getHour());
System.out.println(c5.getMinute());
System.out.println(c5.getSecond());
System.out.println((DigitalClock)c5.getTime());
System.out.println((DigitalClock)c5.getSecond());
```

OUTPUT

```
>> 1:22:52pm
>> 1
>> 22
>> 52
>> 1:22:52pm
>> This last one is a compilation error. (DigitalClock doesn't have a getSecond() method)
```

## DigitalClock Puzzles (Continued, Continued) 11

### DigitalClock Puzzle #5

```
1 DigitalClock c6 = new DigitalClock(); //hour=13,minute=22
2 System.out.println((PreciseDigitalClock)c6.getSecond());
3 System.out.println((PreciseDigitalClock)c6.getTime());
4 System.out.println((PreciseDigitalClock)c6.getSecond());
```

**All of these are `ClassCastExceptions`. A `new DigitalClock()` is NOT a `PreciseDigitalClock`**

Now, we do the same idea with a **mystery** problem!

## Polymorphism Mystery 12

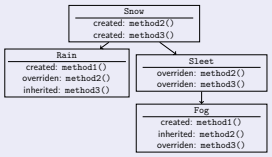
```
1  public class Snow {
2     public void method2() {
3        System.out.println("Snow 2");
4     }
5     public void method3() {
6        System.out.println("Snow 3");
7     }
8  }
```

```
1  public class Sleet extends Snow {
2     public void method2() {
3        System.out.println("Sleet 2");
4        super.method2();
5        this.method3();
6     }
7     public void method3() {
8        System.out.println("Sleet 3");
9     }
10 }
```

```
1  public class Rain extends Snow {
2     public void method1() {
3        System.out.println("Rain 1");
4     }
5     public void method2() {
6        System.out.println("Rain 2");
7     }
8  }
```

```
1  public class Fog extends Sleet {
2     public void method1() {
3        System.out.println("Fog 1");
4     }
5     public void method3() {
6        System.out.println("Fog 3");
7     }
8  }
```

### Class Diagram




## Mystery Problems 13

### Keep the following rules in mind

- If the type on the left doesn't have a method, we can't call it.
- When calling a method, the **version** called is always the **actual type**.
- Casting **up** the tree is the only type that is okay.

### What do each of the following do? (error? print what?)

```
Snow var2 = new Rain();
var2.method2();
```

```
Snow var2 = new Sleet();
var2.method2();
```

```
Snow var2 = new Fog();
((Sleet)var2).method2();
```

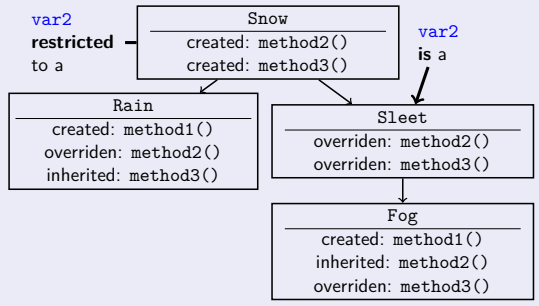
```
Snow var2 = new Rain();
var2.method2();
```

```
Snow var2 = new Rain();
((Rain) var2).method1();
```

```
Snow var2 = new Rain();
((Sleet) var2).method2();
```

## Mystery Problem #1 14

### Class Diagram



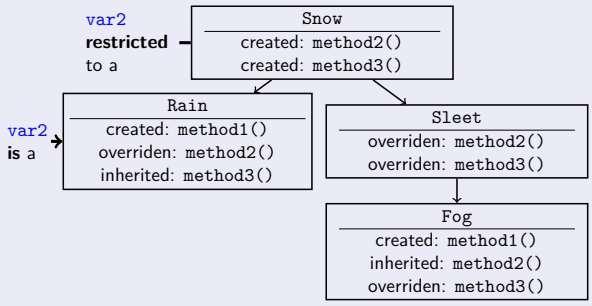

```
Snow var2 = new Sleet();
var2.method2();
```

OUTPUT

```
>> Sleet 2
>> Snow 2
>> Sleet 3
```

## Mystery Problem #2 15

### Class Diagram



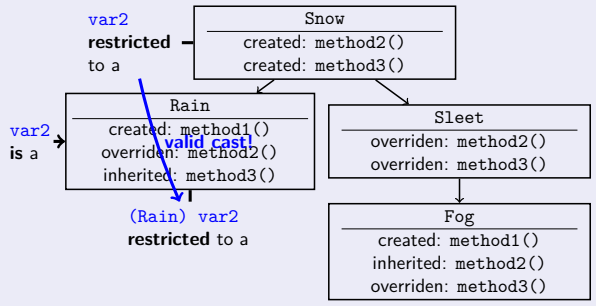

```
Snow var2 = new Rain();
var2.method1();
```

OUTPUT

```
>> Rain 2
```

## Mystery Problem #3 16

### Class Diagram



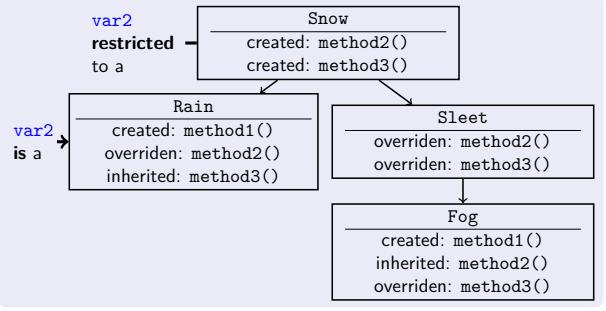

```
Snow var2 = new Rain();
((Rain) var2).method1();
```

OUTPUT

```
>> Rain 1
```

## Mystery Problem #4 17

Class Diagram



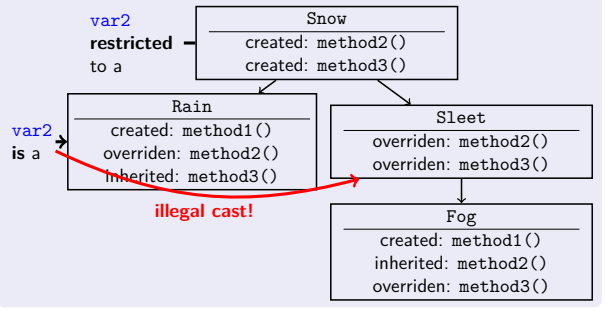

```
Snow var2 = new Rain();
var2.method2();
```

OUTPUT

```
>> Rain 2
```

## Mystery Problem #5 18

Class Diagram



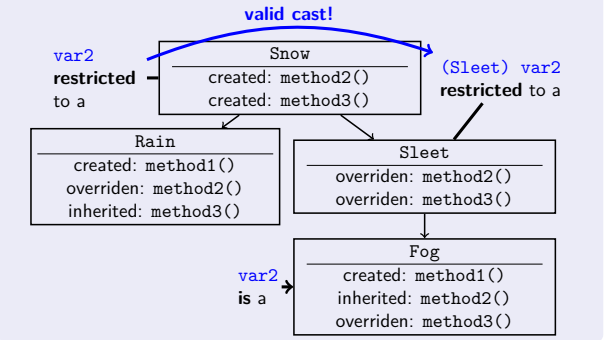

```
Snow var2 = new Rain();
((Sleet) var2).method2();
```

OUTPUT

```
>> ClassCastException: *Error*
```

## Mystery Problem #6 19

Class Diagram




```
Snow var2 = new Fog();
((Sleet)var2).method2();
```

OUTPUT

```
>> Sleet 2
>> Snow 2
>> Fog 3
```