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Inheritance and Polymorphism

Dasar – Dasar Pemrograman 2

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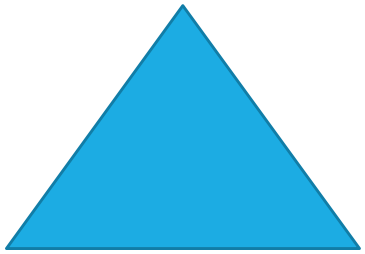
Credits

- Liang, Introduction to Java Programming, 11th Edition, Ch. 1
- Downey & Mayfield, Think Java: How to Think Like a Computer Scientist, Ch. 1
- Slide Kuliah Dasar-Dasar Pemrograman 2 Semester Genap 2019/2020

Motivation

- We have some objects, Define the Classes of these objects!



- Color
- Filled
- Height
- Base

- Color
- Filled
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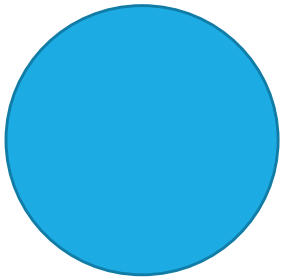

- Color
- Filled
- Diameter

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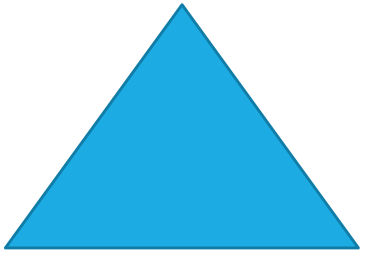
Motivation

- We have some objects, Define the Classes of these objects!



- Color
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- Color
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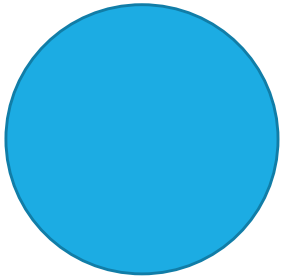

- Color
- Filled
- Diameter

These classes have common features. What is the best way to design these classes so to avoid redundancy?

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Inheritance

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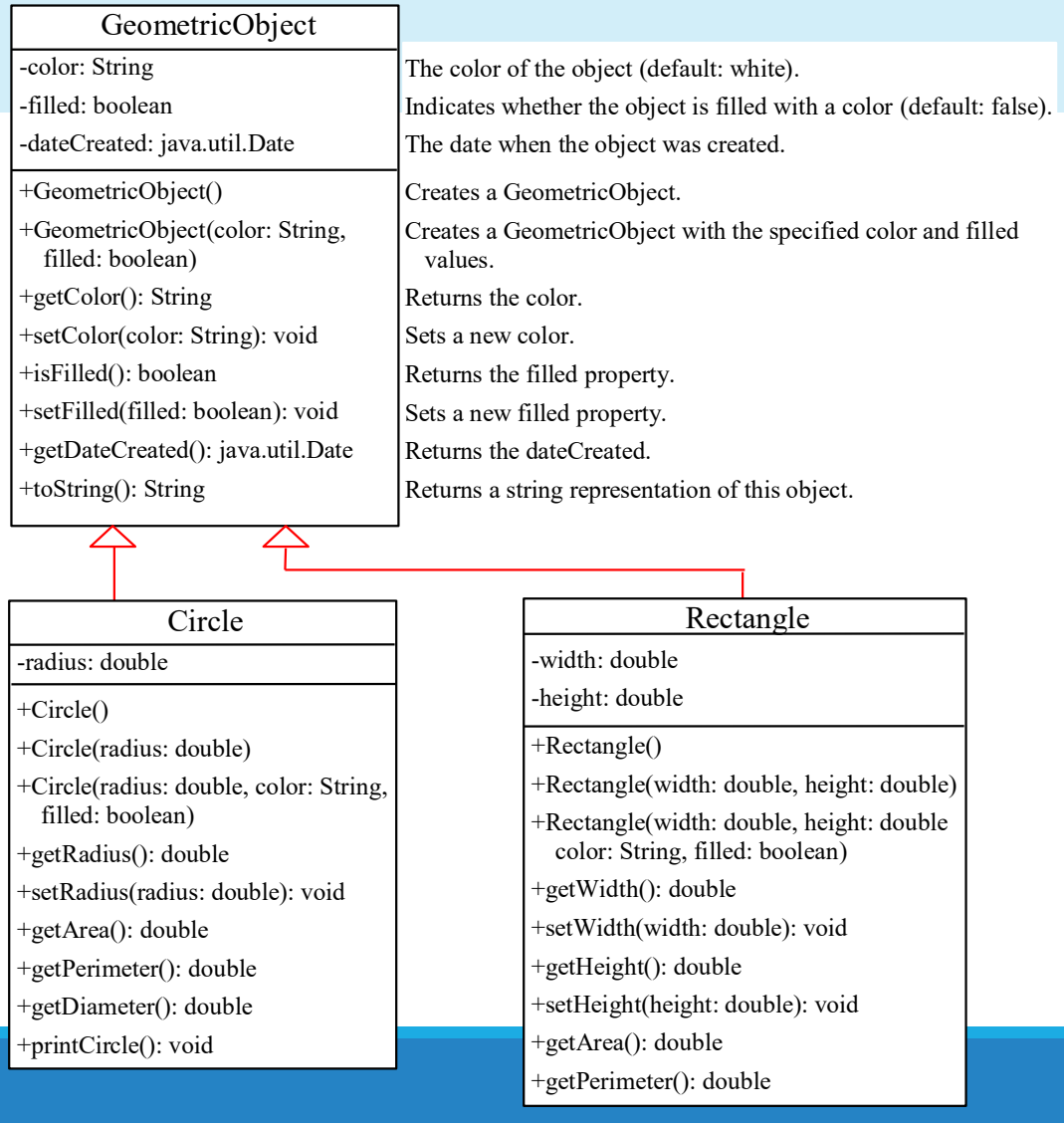
Superclasses and Subclasses

Superclass = parent class / base class
Subclass = derived class / extended class / child class

Subclass memiliki hubungan IS-A dengan superclass.

Setiap subclass mewarisi field (atribut), method, dan nested class dari superclass.

Yang tidak dapat diwariskan:
-. Constructor



Geometric Object

GeometricObject	
-color: String	The color of the object (default: white).
-filled: boolean	Indicates whether the object is filled with a color (default: false).
-dateCreated: java.util.Date	The date when the object was created.
+GeometricObject()	Creates a GeometricObject.
+GeometricObject(color: String, filled: boolean)	Creates a GeometricObject with the specified color and filled values.
+getColor(): String	Returns the color.
+setColor(color: String): void	Sets a new color.
+isFilled(): boolean	Returns the filled property.
+setFilled(filled: boolean): void	Sets a new filled property.
+getDateCreated(): java.util.Date	Returns the dateCreated.
+toString(): String	Returns a string representation of this object.

```
public class GeometricObject{
   private String color = "white";
   private boolean filled;
   private java.util.Date dateCreated;
```

https://liveexample.pearsoncmg.com/html/SimpleGeometricObject.html

Circle

Circle
-radius: double
+Circle() +Circle(radius: double) +Circle(radius: double, color: String, filled: boolean) +getRadius(): double +setRadius(radius: double): void +getArea(): double +getPerimeter(): double +getDiameter(): double +printCircle(): void

```
public class Circle extends GeometricObject{
      private double radius;
```

Keyword extends digunakan untuk menjadikan suatu class sebagai turunan dari class lain.

https://liveexample.pearsoncmg.com/html/CircleFromSimpleGeometricObject.html

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Rectangle

Rectangle
-width: double -height: double
+Rectangle() +Rectangle(width: double, height: double) +Rectangle(width: double, height: double color: String, filled: boolean) +getWidth(): double +setWidth(width: double): void +getHeight(): double +setHeight(height: double): void +getArea(): double +getPerimeter(): double

```
public class Rectangle extends GeometricObject{
      private double width;
      private double height;
```

Keyword extends digunakan untuk menjadikan suatu class sebagai turunan dari class lain.

https://liveexample.pearsoncmg.com/html/RectangleFromSimpleGeometricObject.html

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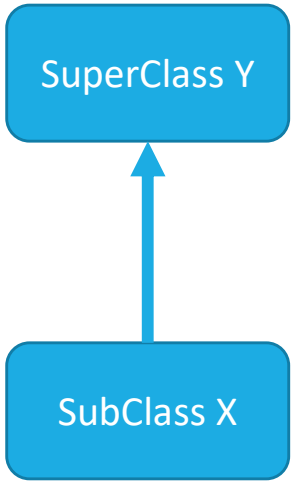
Are superclass's Constructor Inherited?



- **Subclass Inherits all Properties and methods**
- Unlike properties and methods, a superclass's constructors are not inherited in the subclass.
- They can only be invoked from the subclasses' constructors, using the keyword **super**.
- *If the keyword **super** is not explicitly used, the superclass's no-arg constructor is automatically invoked.*

Using the Keyword `super`

The keyword super refers to the superclass of the class in which super appears.

The keyword can be used in two ways:

- To call a superclass constructor
- To call a superclass method

Superclass's Constructor Is Always Invoked

- A constructor may invoke an overloaded constructor or its superclass's constructor.
- If none of them is invoked explicitly, the compiler puts **super()** as the first statement in the constructor.

```
public A() {
}
```

is equivalent to

```
public A() {
  super();
}
```

```
public A(double d) {
  // some statements
}
```

is equivalent to

```
public A(double d) {
  super();
  // some statements
}
```

Using the Keyword `super`

Caution!

- You must use the keyword **`super`** to call the superclass constructor.
- Invoking a **superclass constructor's name** in a subclass causes a **syntax error**.
- Java requires that the statement that uses the keyword **`super`** appear first in the constructor.

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Constructor Chaining

Constructing an instance of a class invokes all the superclasses' constructors along the inheritance chain. This is known as *constructor chaining*.

Konstruktor Berjenjang :

- subclass yang paling bawah akan memanggil konstruktor dari superclass di atasnya.
- konstruktor superclass atas tersebut juga memanggil konstruktor superclass lain yang lebih atas dan seterusnya.

Constructor Chaining

First Super Class is ‘Person’

```
class Person {
  public Person() {
     System.out.println("(1) Person's no-arg constructor
     is invoked");
  }
}
```

Constructor Chaining

Second Class that extends from 'Person' class is Employee, the Employee is Subclass from Person class.

```
class Employee extends Person {
  public Employee() {
      this("(2) Invoke Employee's overloaded
      constructor");
      System.out.println("(3) Employee's no-arg
      constructor is invoked");
  }

  public Employee(String s) {
    System.out.println(s);
  }
}
```

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Constructor Chaining

And the Employee have a sub class, the Faculty class.

```
public class Faculty extends Employee {
  public static void main(String[] args) {
     new Faculty();
  }

  public Faculty() {
     System.out.println("(4) Faculty's no-arg constructor
     is invoked");
  }
}
```

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Trace Execution of Constructor Chaining

```
public class Faculty extends Employee {
  public static void main(String[] args) {
    new Faculty();
  }

  public Faculty() {
    System.out.println("(4) Faculty's no-arg constructor is invoked");
  }
}

class Employee extends Person {
  public Employee() {
    this("(2) Invoke Employee's overloaded constructor");
    System.out.println("(3) Employee's no-arg constructor is invoked");
  }

  public Employee(String s) {
    System.out.println(s);
  }
}

class Person {
  public Person() {
    System.out.println("(1) Person's no-arg constructor is invoked");
  }
}
```

1. Start from the main method

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Trace Execution of Constructor Chaining

```
public class Faculty extends Employee {
  public static void main(String[] args) {
    new Faculty();
  }

  public Faculty() {
    System.out.println("(4) Faculty's no-arg constructor is invoked");
  }
}

class Employee extends Person {
  public Employee() {
    this("(2) Invoke Employee's overloaded constructor");
    System.out.println("(3) Employee's no-arg constructor is invoked");
  }

  public Employee(String s) {
    System.out.println(s);
  }
}

class Person {
  public Person() {
    System.out.println("(1) Person's no-arg constructor is invoked");
  }
}
```

2. Invoke Faculty constructor

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Trace Execution of Constructor Chaining

```
public class Faculty extends Employee {
  public static void main(String[] args) {
    new Faculty();
  }

  public Faculty() {
    System.out.println("(4) Faculty's no-arg constructor is invoked");
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}

class Employee extends Person {
  public Employee() {
    this("(2) Invoke Employee's overloaded constructor");
    System.out.println("(3) Employee's no-arg constructor is invoked");
  }

  public Employee(String s) {
    System.out.println(s);
  }
}

class Person {
  public Person() {
    System.out.println("(1) Person's no-arg constructor is invoked");
  }
}
```

3. Invoke Employee's no-arg constructor

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Trace Execution of Constructor Chaining

```
public class Faculty extends Employee {
  public static void main(String[] args) {
    new Faculty();
  }

  public Faculty() {
    System.out.println("(4) Faculty's no-arg constructor is invoked");
  }
}

class Employee extends Person {
  public Employee() {
    this("(2) Invoke Employee's overloaded constructor");
    System.out.println("(3) Employee's no-arg constructor is invoked");
  }

  public Employee(String s) {
    System.out.println(s);
  }
}

class Person {
  public Person() {
    System.out.println("(1) Person's no-arg constructor is invoked");
  }
}
```

4. Invoke Employee(String) constructor

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Trace Execution of Constructor Chaining

```
public class Faculty extends Employee {
  public static void main(String[] args) {
    new Faculty();
  }

  public Faculty() {
    System.out.println("(4) Faculty's no-arg constructor is invoked");
  }
}

class Employee extends Person {
  public Employee() {
    this("(2) Invoke Employee's overloaded constructor");
    System.out.println("(3) Employee's no-arg constructor is invoked");
  }

  public Employee(String s) {
    System.out.println(s);
  }
}

class Person {
  public Person() {
    System.out.println("(1) Person's no-arg constructor is invoked");
  }
}
```

5. Invoke Person() constructor

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Trace Execution of Constructor Chaining

```
public class Faculty extends Employee {
  public static void main(String[] args) {
    new Faculty();
  }

  public Faculty() {
    System.out.println("(4) Faculty's no-arg constructor is invoked");
  }
}

class Employee extends Person {
  public Employee() {
    this("(2) Invoke Employee's overloaded constructor");
    System.out.println("(3) Employee's no-arg constructor is invoked");
  }

  public Employee(String s) {
    System.out.println(s);
  }
}

class Person {
  public Person() {
    System.out.println("(1) Person's no-arg constructor is invoked");
  }
}
```

6. Execute println

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Trace Execution of Constructor Chaining

```
public class Faculty extends Employee {
  public static void main(String[] args) {
    new Faculty();
  }

  public Faculty() {
    System.out.println("(4) Faculty's no-arg constructor is invoked");
  }
}

class Employee extends Person {
  public Employee() {
    this("(2) Invoke Employee's overloaded constructor");
    System.out.println("(3) Employee's no-arg constructor is invoked");
  }

  public Employee(String s) {
    System.out.println(s);
  }
}

class Person {
  public Person() {
    System.out.println("(1) Person's no-arg constructor is invoked");
  }
}
```

7. Execute println

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Trace Execution of Constructor Chaining

```
public class Faculty extends Employee {
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  public Faculty() {
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class Employee extends Person {
  public Employee() {
    this("(2) Invoke Employee's overloaded constructor");
    System.out.println("(3) Employee's no-arg constructor is invoked");
  }

  public Employee(String s) {
    System.out.println(s);
  }
}

class Person {
  public Person() {
    System.out.println("(1) Person's no-arg constructor is invoked");
  }
}
```

8. Execute println

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Trace Execution of Constructor Chaining

```
public class Faculty extends Employee {
  public static void main(String[] args) {
    new Faculty();
  }

  public Faculty() {
    System.out.println("(4) Faculty's no-arg constructor is invoked");
  }
}

class Employee extends Person {
  public Employee() {
    this("(2) Invoke Employee's overloaded constructor");
    System.out.println("(3) Employee's no-arg constructor is invoked");
  }

  public Employee(String s) {
    System.out.println(s);
  }
}

class Person {
  public Person() {
    System.out.println("(1) Person's no-arg constructor is invoked");
  }
}
```

9. Execute println

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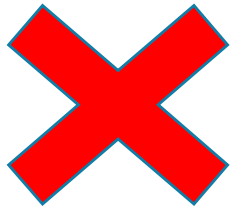
Example on the Impact of a Superclass without no-arg Constructor

```
public class Apple extends Fruit {
}

class Fruit {
  public Fruit(String name) {
    System.out.println("Fruit's constructor is invoked");
  }
}
```



- Error karena Class Constructor dengan parameter di Superclass harus di akses di class Child/ Sub class

Example on the Impact of a Superclass without no-arg Constructor

```
public class Apple extends Fruit {

}

class Fruit {

  public Fruit(String name) {
    System.out.println("Fruit's constructor is invoked");
  }
}
```

Add a constructor with a call to `super("name");` here

Or Add a no-argument constructor here

Example on the Impact of a Superclass without no-arg Constructor **Solution!**

```
public class Apple extends Fruit {
    public Apple(String name){
        super(name);
    }
}

class Fruit {
    String name;
    public Fruit(String name) {
        this.name = name;
        System.out.println("Fruit's constructor is invoked");
    }
}
```

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Defining a Subclass

A subclass inherits from a superclass. You can also:

- Add new properties
- Add new methods
- **Override the methods** of the superclass

Calling Superclass Methods

You could rewrite the printCircle() method in the Circle class

```
public void printCircle() {
  System.out.println("The circle is created " +
    super.getDateCreated() + " and the radius is " + radius);
}
```

Overriding Methods in the Superclass

A subclass inherits methods from a superclass. Sometimes it is necessary for the subclass to modify the implementation of a method defined in the superclass. This is referred to as ***method overriding***.

```
public class Circle extends GeometricObject {


  /** Override the toString method defined in GeometricObject */
  public String toString() {
    return super.toString() + "\nradius is " + radius;
  }

}
```

Overriding Methods in the Superclass

```
public class GeometricObject {

   private String toString() {
      return "created on " + dateCreated + "\ncolor: " + color +
      " and filled: " + filled;
   }

}
```

How about if Like This? It's Still Override?

```
public class Circle extends GeometricObject {

   public String toString() {
      return super.toString() + "\nradius is " + radius;
   }

}
```

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Overriding vs. Overloading

- Kunci dari Overriding “Jika kita ingin megubah fungsi dari method yang ada di Super Class”.

```
public class Test {
  public static void main(String[] args) {
    A a = new A();
    a.p(10);
    a.p(10.0);
  }
}

class B {
  public void p(double i) {
    System.out.println(i * 2);
  }
}

class A extends B {
  // This method overrides the method in B
  public void p(double i) {
    System.out.println(i);
  }
}
```

```
public class Test {
  public static void main(String[] args) {
    A a = new A();
    a.p(10);
    a.p(10.0);
  }
}

class B {
  public void p(double i) {
    System.out.println(i * 2);
  }
}

class A extends B {
  // This method overloads the method in B
  public void p(int i) {
    System.out.println(i);
  }
}
```

NOTE!

- An instance method can be overridden only if it is **accessible**.
- Thus a private method **cannot be overridden**, because it is **not accessible outside** its **own class**.
- If a method defined in a subclass is private in its superclass, the two methods are completely unrelated.

NOTE!

- Like an instance method, a static method can be inherited.
- However, a static method cannot be overridden.
- If a static method defined in the superclass is redefined in a subclass, the method defined in the superclass is hidden.

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The Object Class and Its Methods

- Every class in Java is descended from the java.lang.Object class.
- If no inheritance is specified when a class is defined, the superclass of the class is Object.

```
public class Circle {
   ...
}
```

Equivalent

```
public class Circle extends Object {
   ...
}
```

The toString() method in Object

- The toString() method returns a string representation of the object.
- The default implementation returns a string consisting of a class name of which the object is an instance, the at sign (@), and a number representing this object.

```
Loan loan = new Loan();
System.out.println(loan.toString());
```

- The code displays something like Loan@15037e5 . This message is not very helpful or informative.
- Usually you should override the toString method so that it returns a digestible string representation of the object.