- Objectives when we have completed this set of notes, you should be familiar with:
 - deriving new classes from existing classes
 - the protected modifier
 - creating class hierarchies
 - abstract classes
 - indirect visibility of inherited members
 - designing for inheritance



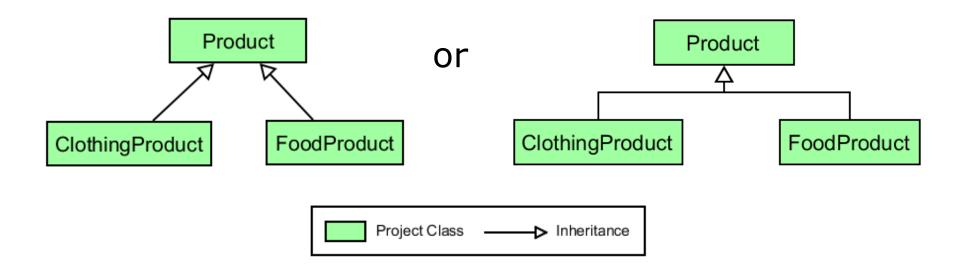
- Suppose that you are creating a program to keep track of products in a store's inventory
- You need to represent the following:
 - General products -> price, name
 - Clothing products -> price, name, size
 - Food products -> price, name, isRefrigerated
- Each of the above classes needs variables for price and name, but the clothing products and food products classes have additional characteristics



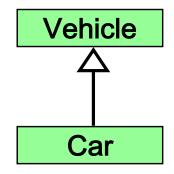
- Possible solutions:
 - Write classes Product, FoodProduct, ClothingProduct and include price and name (and methods) in each
 - Use inheritance so that you only have to write common code once [We'll use this approach!]
- The existing class (<u>Product.java</u>) is the parent class, superclass, or base class
- Each <u>derived</u> class (e.g., FoodProduct, ClothingProduct) is the <u>child class</u> or <u>subclass</u>
- A child classes inherits the variables and methods defined by the parent class



UML Class Diagram* shows inheritance:



• *is-a* relationship: the child *is a* more specific version of the parent



*Open the project file to generate UML Class Diagram



Deriving Subclasses

 In Java, we use the reserved word extends to establish an inheritance relationship

```
public class ClothingProduct extends Product {
}
```

- We say ClothingProduct is derived from Product; or ClothingProduct is subclass of Product
- Two children of the same parent are called siblings
 - ClothingProduct and FoodProduct are siblings



The protected Modifier

- Variables / methods / constants declared as private cannot be referenced in a child class
 - This is fine unless the child class needs to reference a specific variable or method
- Variables / methods / constants declared with public access can be referenced in a child class
 - But declaring variables as public violates encapsulation!
- Solution: the protected access modifier
 - Only allows subclasses (child classes) and classes in the same package to access the variable



The protected Modifier

 If instance variables for price and name need to be accessed directly in subclasses of Product, we can use the protected modifier:

```
public class Product {
   protected String name;
   protected double price;
}
```

 Variables name and price can now be accessed by FoodProduct and ClothingProduct:

```
public class ClothingProduct extends Product
public class FoodProduct extends Product
```



The super Reference

- Constructors are **not** inherited
- However, you can avoid repeating all of the code in the parent's constructor using the reserved word super
- The first line of a child's constructor can use the super reference to call the parent's constructor (See <u>ClothingProduct</u> constructor)
- The super reference can also be used to reference variables and methods defined in the parent class (See toString in FoodProduct)



Parameterless Constructors

- Recall that Java provides a parameterless constructor for your class if you do not provide a constructor.
- If a constructor in a subclass does not call the super constructor directly, the parameterless constructor of the superclass is automatically called - - - all the way up the hierarchy.
 - If there is no parameterless constructor in the superclass (parent), then you **must** call the super constructor in the child class; otherwise a compiletime error will occur. Modify ClothingProduct so that the super constructor is <u>not</u> called to see this error.

InheritanceExample.java (Open project file to generate UML Class Diagram)



Overriding Methods

- A child class can override the definition of an inherited method
- The new method must have the same signature as the parent's method, but can have a different body
- For example, suppose that food items do not factor tax into their total price
 - The totalPrice method is redefined in FoodProduct



Overriding

- The concept of overriding can be applied to data and is called shadowing variables
 - For example, ClothingProduct could also have a variable called name
 - You would have to use super.name to access the name variable in the parent class
 - Shadowing variables should be avoided because it tends to cause unnecessarily confusing code

The exception would be for class constants since they are usually qualified with the class name



Overloading vs. Overriding

- Recall that overloading deals with multiple methods with the same name but with different signatures
 - Defines a method of the same name as an existing method but with different parameters
- Overriding deals with two methods, one in a parent class and one in a child class, that have the same signature
 - Redefines a method of the parent class (same name and parameters)



The Object Class

- A class called Object is defined in the java.lang package of the Java standard class library
- All classes are derived from the Object class
- If a class is not explicitly defined to be the child of an existing class, it is assumed to be the child of the Object class
- Therefore, the Object class is the ultimate root of all class hierarchies



The Object Class

- The Object class contains a few useful methods, which are inherited by all classes
- For example, the toString method is defined in the Object class
- Every time we define the toString method, we are actually overriding an inherited definition
- The toString method in the Object class is defined to return a string that contains the name of the object's class along with the hash code for the object



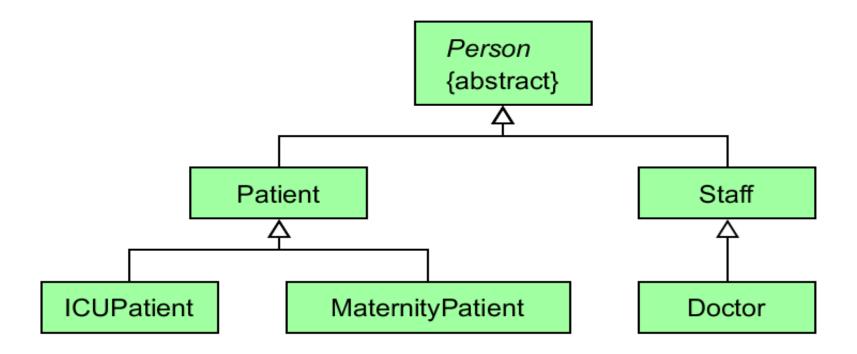
The Object Class

- The equals method of the Object class returns true if two references are aliases
- We can override equals in any class to define equality in some more appropriate way
- The String class has overridden the equals method inherited from Object in favor of a more useful version returns true if two String objects contain the same characters
- Note: If you override the equals method, our Checkstyle rules require the hashCode method to be overridden as well)



Class Hierarchies

 A child class of one parent can be the parent of another child, forming a class hierarchy



(Open the Hospital.gpj project file to generate UML Class Diagram)



Class Hierarchies

- Common features should be put as high in the hierarchy as is reasonable (see <u>Person</u>)
- A child class inherits from all its ancestor classes
 - <u>Doctor</u> inherits all protected and public fields and methods from <u>Staff and Person</u>
 - See the toString method in <u>Doctor.java</u>. It accesses firstName and lastName from Person.java as well as phone in Staff.java

(Open Hospital project file to generate UML Class Diagram)



Abstract Classes

- An abstract class is a placeholder in a class hierarchy that defines certain variables and behavior
- An abstract class cannot be instantiated
- We use the modifier abstract on the class header to declare a class as abstract:
 - Example: We would never really need a "Person" object, but it can define fields and methods common to Patients and Staff

public abstract class Person



Abstract Classes

- An abstract class can contain abstract methods with no definitions (similar to an interface)
 - The abstract modifier must be applied to each abstract method
- The child of an abstract class must override the abstract methods of the parent or it must be declared to be abstract as well
 - getId from Person is defined in Staff, Doctor, and Patient
 - Note that it is **not** defined in ICUPatient and MaternityPatient since it was handled by Patient



Abstract Classes

- Why define abstract methods?
 - The hospital is never going to instantiate a Person object, but methods like getName are selfexplanatory and will be the same for all child classes.
 - The generation of an id is necessary for all child classes, but it's going to be different for patients and staff
- An abstract method cannot be defined as final or static



- Discussion: What are the benefits of inheriting methods and variables from an existing class?
 - Avoiding redundancy
 - Code reuse
 - Testing
 - Maintainability



Multiple Inheritance

- Java supports single inheritance, meaning that a derived class can have only one parent class
- Multiple inheritance allows a class to be derived from two or more classes, inheriting the members of all parents
- Collisions, such as the same variable name in two parents, have to be resolved
- Java does <u>not</u> support multiple inheritance
- In most cases, the use of interfaces gives us aspects of multiple inheritance without the overhead



Interface Hierarchies

- Inheritance can be applied to interfaces as well as classes
- That is, one interface can be derived from another interface
- The child interface inherits all abstract methods of the parent
- A class implementing the child interface must define all methods from both the ancestor and child interfaces



Inheritance Design Issues

- Allow each class to manage its own data; use the super reference to invoke the parent's constructor to set up its data
- Override the toString and equals methods from the Object class with appropriate definitions as needed
- Use abstract classes to represent general concepts that lower classes have in common
- Use visibility modifiers carefully to provide needed access without violating encapsulation



Accessibility Revisited

- Variables and methods of a parent class, are inherited by its children
- Private variables and methods inherited by subclass instances cannot be referenced directly
- However, the subclass can reference them indirectly using its parent's public methods (e.g., getters, setters)
- The super reference can be used to refer to the parent class, even if no object of the parent exists



Restricting Inheritance

- The final modifier can be used to restrict inheritance
- If the final modifier is applied to a class, then that class cannot be used to derive subclasses (e.g., if class A is final then class B cannot extend A)
 - Thus, an abstract class cannot be declared as final
- If the final modifier is applied to a method, then that method cannot be overridden in any descendent classes
- These are key design decisions, establishing that a method or class should be used as is

