CSE201: Monsoon 2024
Advanced Programming

Lecture 04: Interfaces

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Last Lecture

- Class relationships
  - When writing a program, need to keep in mind “big picture”—how are different classes related to each other?
  - **Association**
    - Class A and class B are **associated** if A “**knows about**” B, but B is not a component of A
    - Class A holds a class level reference to class B
  - **Composition**
    - Class A **contains** object of class B
    - A **instantiate** B
    - The death relationship
      - B is garbage collected when A gets garbage collected
  - **Dependency**
    - Neither class A or class B “knows about” each other, nor one of them is a “component” of the other. However, if A requests a service from B then A is said to be dependent on B

```
class Cart {
  private double price;
  public void addProduct(Product P){
    price+=P.getPrice();
  }
}
```

```
class Project {
  private String name;
  public boolean status() { ... }
  .....
}
// Contractor’s project keep changing
class Contractor {
  private Project currentProject;
  public Contractor(Project proj) {
    this.currentProject = proj;
  }
  public void setProject(Project proj){
    this.currentProject = proj;
  }
}
```

```
class Project {
  private String name;
  public boolean status() { ... }
  .....
}
// A manager is fixed for a project
class Manager {
  private Project project;
  public Manager() {
    this.project = new Project(“ABC”);
  }
  public boolean projectCompleted() {
    return project.status();
  }
}
```

This Lecture

- Interfaces in Java
  - Declaring
  - Defining

Slide acknowledgements: CS15, Brown University

Recall: Declaring vs. Defining Methods

- What's the difference between declaring and defining a method?
  - method declaration is the scope (`public`), return type (`void`), name and parameters (`makeSounds()`)
  - method definition is the body of the method – the actual implementation (the code that actually makes the sounds)

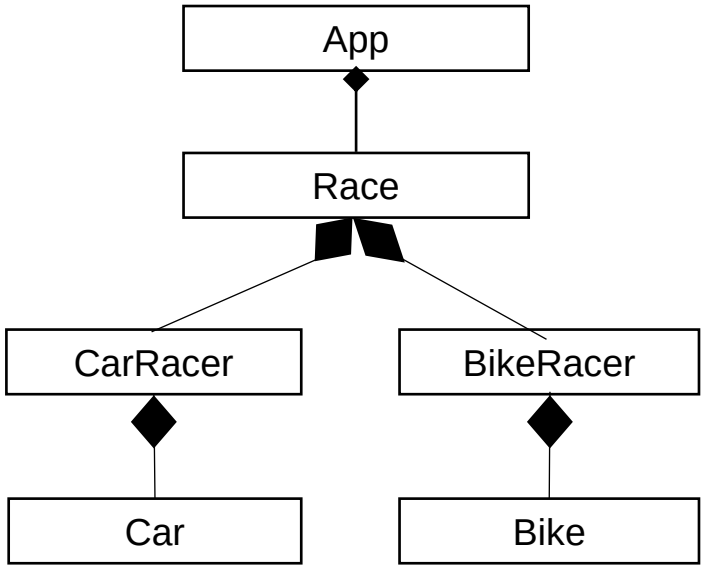
```
public class Dog {
    //constructor elided

    public void makeSounds() {
        this.bark();
        this.whine();
        this.bark();
    }
    public void bark() {
        //code elided
    }
    public void whine() {
        //code elided
    }
}
```

Using What You Know

- Imagine this program:
  - Sophia and Dan are racing from their home to city center
    - whoever gets there first, wins!
    - catch: they don't get to choose their method of transportation
- Design a program that
  - assigns mode of transportation to each racer
  - starts the race
- For now, assume transportation options are `Car` and `Bike`

What does our design look like?



- Imagine this program:
  - Sophia and Dan are racing from their home to city center
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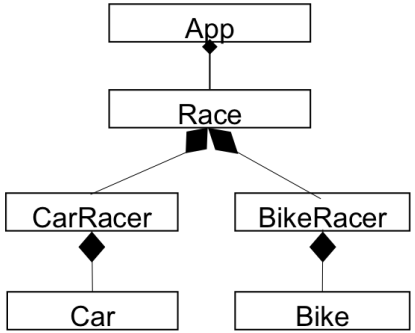
Goal 1: Assign transportation to each racer

- Need transportation classes (something to give to racers)
- Let's use `Car` and `Bike` classes
- Both classes will need to describe how the transportation moves
  - `Car` needs `drive` method
  - `Bike` needs `pedal` method

Coding the project (1/4)



- Let's build transportation classes

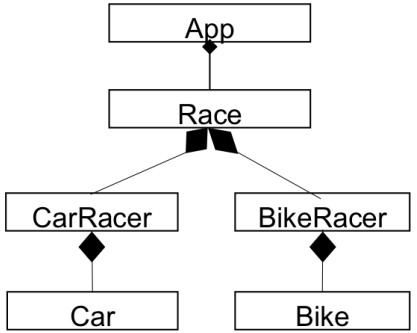
```
public class Car {

    public Car() {//constructor
        //code elided
    }
    public void drive(){
        //code elided
    }
    //more methods elided
}
```

```
public class Bike {

    public Bike() {//constructor
        //code elided
    }
    public void pedal(){
        //code elided
    }
    //more methods elided
}
```

Goal 1: Assign transportation to each racer

- Need racer classes that will use their type of transportation
  - `CarRacer`
  - `BikeRacer`
- What methods will we need? What capabilities should each `-Racer` class have?
- `CarRacer` needs to know when to use the car
  - write `useCar()` method
- `BikeRacer` needs to know when to use the bike
  - write `useBike()` method

Coding the project (2/4)



- Let's build the racer classes

```
public class CarRacer {
    private Car _car;

    public CarRacer() {
        _car = new Car();
    }

    public void useCar(){
        _car.drive();
    }
    //more methods elided
}
```

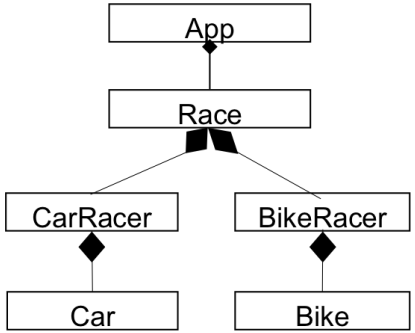
```
public class BikeRacer {
    private Bike _bike;

    public BikeRacer() {
        _bike = new Bike();
    }

    public void useBike(){
        _bike.pedal();
    }
    //more methods elided
}
```

Goal 2: Tell the racers to start the race

- `Race` class contains `Racers`
  - `App` contains `Race`
- `Race` class will have `startRace()` method
  - `startRace()` tells each racer to use their transportation
- `startRace()` gets called in `App`

```
startRace:
    Tell _dan to useCar
    Tell _sophia to useBike
```

Coding the project (3/4)

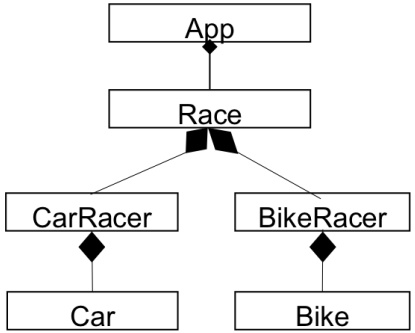


- Let's build the `Race` class

```
public class Race {
    private CarRacer _dan;
    private BikeRacer _sophia;

    public Race() {
        _dan = new CarRacer();
        _sophia = new BikeRacer();
    }

    public void startRace() {
        _dan.useCar();
        _sophia.useBike();
    }
}
```

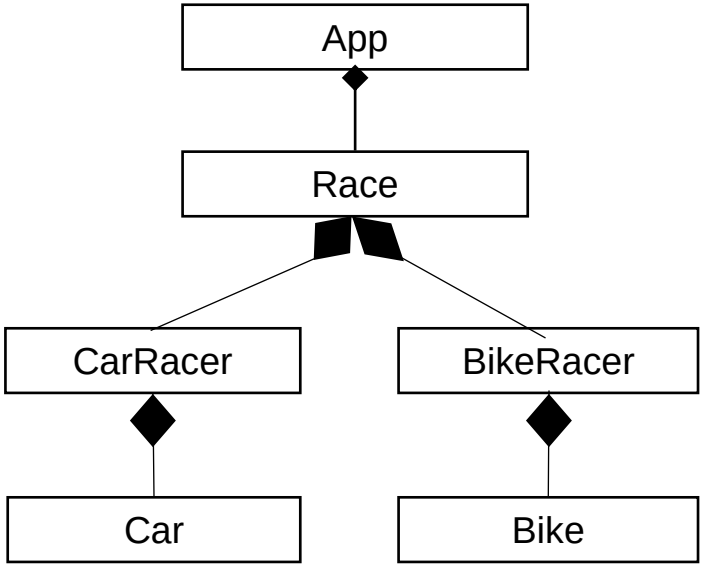
Coding the project (4/4)

```
public class App {
    Race race;
    public App() {
        race = new Race();
        race.startRace();
    }

    public static void main (String[] args) {
        new App();
    }
}
```



- Now build the App class
- Now the race to the city center!

Recap: What does our design look like?



How would this program run?

- An instance of `App` gets initialized
- `App`'s constructor initializes an instance of `Race`
- `Race`'s constructor initializes `_dan` (`CarRacer`) and `_sophia` (`BikeRacer`)
  - `CarRacer`'s constructor initializes a `_car` (Car)
  - `BikeRacer`'s constructor initializes a `_bike`
- App calls `race.startRace()`
- `race` calls `_dan.useCar()` and `_sophia.useBike()`
- `_dan` calls `_car.drive()`
- `_sophia` calls `_bike.pedal()`

Can we do better?

Things to think about

- Do we need two different `Racer` classes?
  - Want multiple instances of `Racers` that use different modes of transportation
  - But how?

Solution 1: Create one `Racer` class with methods!

- Create one `Racer` class
  - define different methods for each type of transportation
- `_dan` is instance of `Racer` and elsewhere we have:

```
Car dansCar = new Car();
_dan.useCar(dansCar);
```

  - `Car`'s `drive()` method will be invoked
- But any given instance of `Racer` will need a new method to accommodate every kind of transportation!

```
public class Racer {
    public Racer(){
        //constructor
    }

    public void useCar(Car myCar){
        myCar.drive();
    }

    public void useBike(Bike myBike){
        myBike.pedal();
    }
}
```

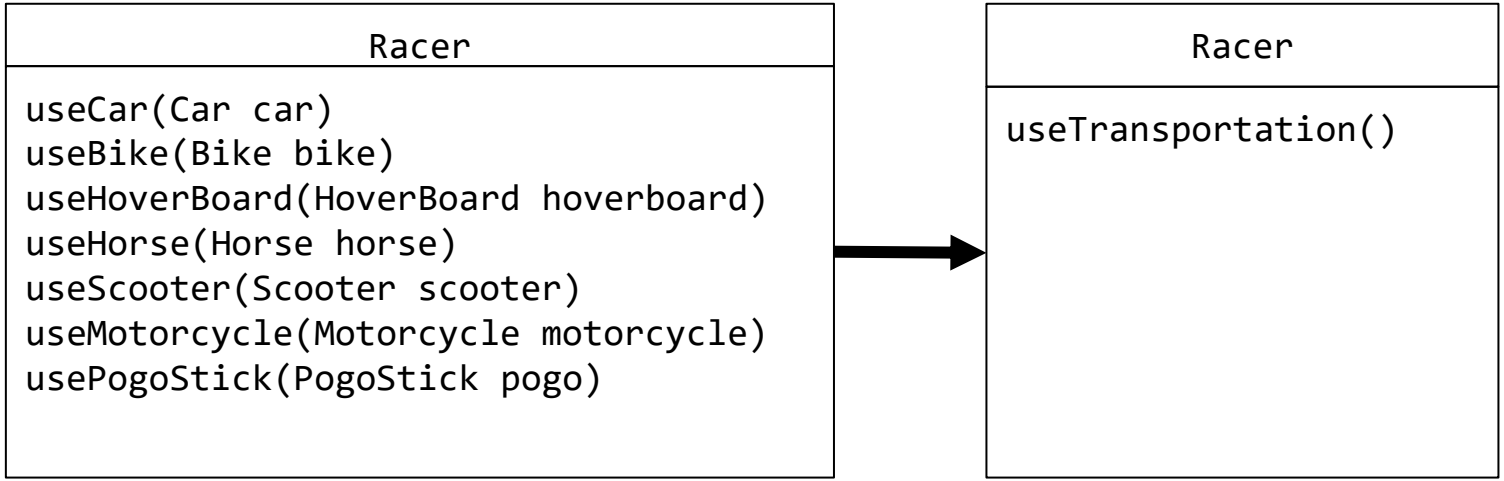
Question: What is the relationship between Racer+Car and Racer+Bike?

Solution 1 Drawbacks

- Now imagine 10 people join the race and so there are 10 different modes of transportation
- Writing these similar `useType()` methods are a lot of work for you, the developer, and inefficient coding style

```
public class Racer {

    public Racer() {
        //constructor
    }
    public void useCar(Car myCar){//code elided}
    public void useBike(Bike myBike){//code elided}
    public void useHoverboard(Hoverboard myHb){//code elided}
    public void useHorse(Horse myHorse){//code elided}
    public void useScooter(Scooter myScooter){//code elided}
    public void useMotorcycle(Motorcycle myMc) {//code elided}
    public void usePogoStick(PogoStick myPogo){//code elided}
    // And more…
}
```

Is there another solution?

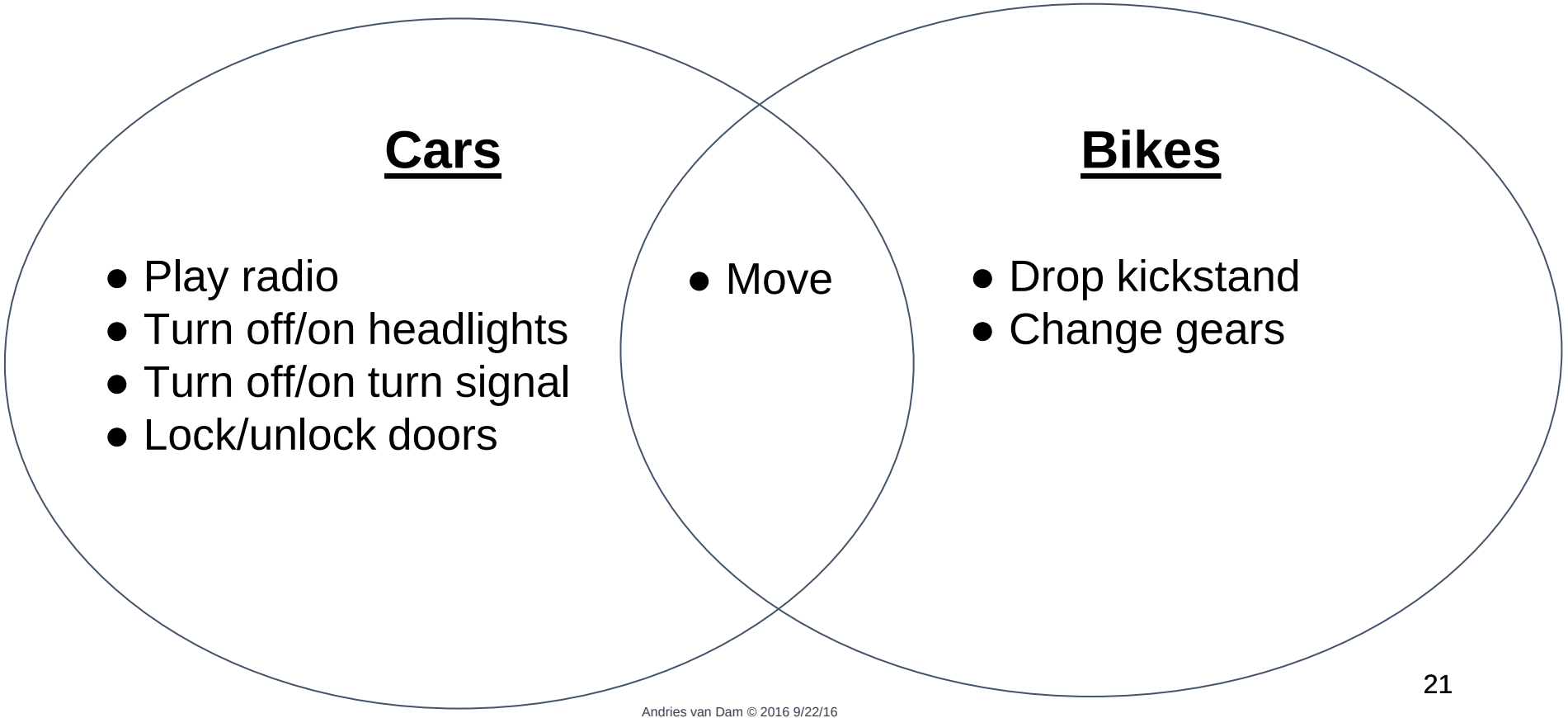


- Can we go from left to right?

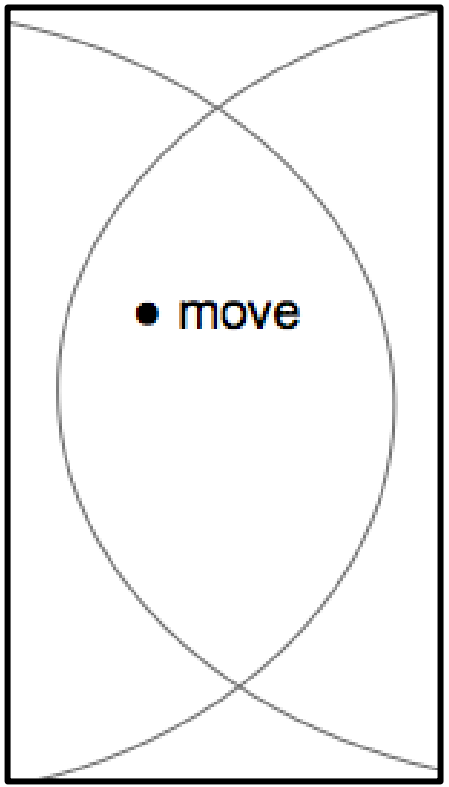
Interfaces: Spot the Similarities

- What do cars and bikes have in common?
- What do cars and bikes not have in common?

Cars vs. Bikes



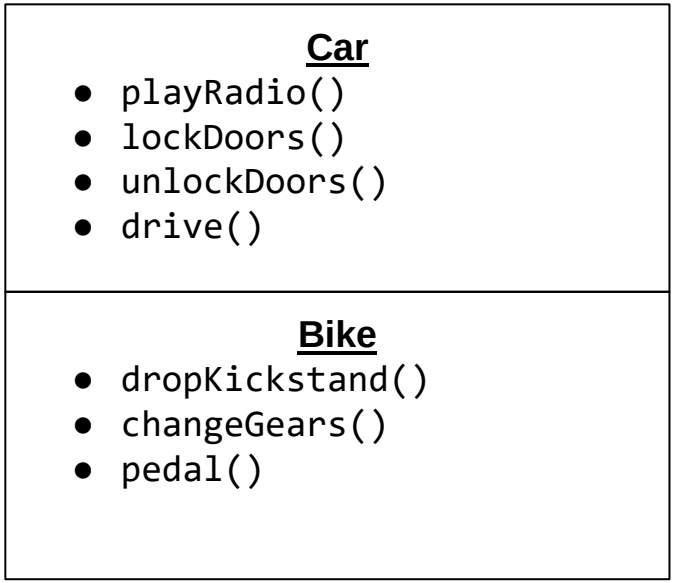
Digging deeper into the similarities



- How similar are they when they move?
  - do they move in same way?
- Not very similar
  - cars drive
  - bikes pedal
- Both can move, but in different ways

Can we model this in code?

- Many real-world objects have several broad similarities
  - cars and bikes can move
  - cars and laptops can play radio
- Take `Car` and `Bike` class
  - how can their similar functionalities get enumerated in one place?
  - how can their broad relationship get portrayed through code?



Introducing Interfaces

- Interfaces group similar capabilities/function of different classes together
- Model “acts-as” relationship
- `Car`s and `Bike`s could implement a `Transporter` interface
  - they can transport people from one place to another
  - “act as” transporters
    - objects that can move
    - have shared functionality, such as moving, braking, turning etc.
  - for this lecture, interfaces are green and classes that implement them pink

Introducing Interfaces

- Interfaces are contracts that classes agree to
- If classes choose to implement given interface, it must define all methods declared in interface
  - if classes don't implement one of interface's methods, the compiler raises error
    - later we'll discuss strong motivations for this contract enforcement
- Interfaces don't define their methods - implementing classes do
  - Interfaces only care about the fact that the methods get defined - not how – *implementation-agnostic*
- **Models similarities while ensuring consistency**
  - **What does this mean?**

Let’s break that down

1) Models Similarities

2) Ensures Consistency

Models Similarities While **Ensuring Consistency**

- How does this help our program?
- We know `Car`s and `Bike`s both need to move
  - i.e., should all have some `move()`method
  - let compiler know that too!
- Let's make the `Transporter` interface!
  - what methods should the `Transporter` interface declare?
    - `move()`
    - only using a `move()` for simplicity, but `brake()`, etc. would also be useful
  - compiler doesn't care how method is defined, just that it's been defined
  - general tip: methods that interface declares should model functionality all implementing classes share

Declaring an Interface (1/4)

What does this look like?

```
public interface Transporter {

    public void move();

}
```

- That's it!
- Interfaces, just like classes, have their own `.java` file. This file would be `Transporter.java`

Declaring an Interface (2/4)

What does this look like?

```
public interface Transporter {

    public void move();

}
```

- Declare it as interface rather than class

Declaring an Interface (3/4)

What does this look like?

```
public interface Transporter {

    public void move();

}
```

- Declare methods - the contract
- In this case, only one method required: `move()`
- All classes that sign contract (implement this interface) must define actual implementation of any declared methods

Declaring an Interface (4/4)

What does this look like?

```
public interface Transporter {

    public void move();

}
```

- Interfaces are only contracts, not classes that can be instantiated
- Interfaces can only declare methods - not define them
- Notice: method declaration end with semicolons, not curly braces!

Implementing an Interface (1/6)

Let's modify `Car`

```
public class Car implements Transporter {

    public Car() {
        // constructor
    }

    public void drive() {
        // code for driving the car
    }

}
```

- Let's modify `Car` to implement `Transporter`
  - declare that `Car` "acts-as" `Transporter`
- Add `implements Transporter` to class declaration
- Promises compiler that `Car` will define all methods in `Transporter` interface
  - i.e., `move()`
- Will this code compile?

Implementing an Interface (2/6)

```
public class Car implements Transporter {

    public Car() {
        // constructor
    }

    public void drive() {
        // code for driving the car
    }

}
```

"Error: Car does not override method move() in Transporter" *

- Will this code compile?
  - nope :(
- Never implemented `move()` and `drive()` - doesn't suffice. Compiler will complain accordingly

*Note: the full error message is "`Car is not abstract and does not override abstract method move() in Transporter`." We'll get more into the meaning of abstract in a later lecture.

Implementing an Interface (3/6)

```
public class Car implements Transporter {

    public Car() {
        // constructor
    }

    public void drive() {
        //code for driving car
    }

    @Override
    public void move() {
        this.drive();
    }

}
```

- Next: honor contract by defining a `move()` method
- Method ***signature*** (name and number/type of arguments) must match how its declared in interface

Implementing an Interface (4/6)

What does `@Override` mean?

```
public class Car implements Transporter {

    public Car() {
        // constructor
    }

    public void drive() {
        //code for driving car
    }

    @Override
    public void move() {
        this.drive();
    }

}
```

- Include `@Override` right above the method signature
- `@Override` is an annotation – a signal to the compiler (and to anyone reading your code)
  - allows compiler to enforce that interface actually has method declared
  - more explanation of `@Override` in next lecture
- Annotations, like comments, have no effect on how code behaves at runtime

Implementing an Interface (5/6)

- Defining interface method is like defining any other method
- Definition can be as complex or as simple as it needs to be
- Ex.: Let's modify `Car`'s move method to include braking
- What will instance of `Car` do if `move()` gets called on it?

```
public class Car implements Transporter {
    public Car() {
        //code elided
    }
    public void drive(){
        //code elided
    }
    @Override
    public void move(){
        this.drive();
        this.brake();
        this.drive();
    }
    //more methods elided
}
```

```
public class Racer {

    //previous code elided
    public void useTransportation(
          Transporter transport) {
        transport.move(); //Polymorphism
    }

}
```

Implementing an Interface (6/6)

- As with signing multiple contracts, classes can implement multiple interfaces
  - “I signed my rent agreement, so I'm a renter, but I also signed my employment contract, so I'm an employee. I'm the same person.”
  - what if I wanted `Car` to change color as well?
  - create a `Colorable` interface
  - add that interface to `Car`’s class declaration
- Implementing class must define every single method in each of its interfaces

```
public interface Colorable {

    public void setColor(Color c);
    public Color getColor();

}

public class Car implements Transporter, Colorable{

    public Car(){ //body elided }
    public void drive(){ //body elided }
    public void move(){ //body elided }
    public void setColor(Color c){ //body elided }
    public Color getColor(){ //body elided  }
}
```

Summary

- Interfaces are formal contracts and ensure consistency
  - compiler will check to ensure all methods declared in interface are defined
- Can trust that any object from class that implements `Transporter` can `move()`
- Will know how 2 classes are related if both implement `Transporter`

Question

Given the following interface:

```
public interface Clickable {
    public void click();
}
```

Which of the following would work as an implementation of the Clickable interface? (don't worry about what changeXPosition does)

A.

```
public void click() {
    this.changeXPosition(100.0);
}
```

B.

```
public void click(double xPosition) {
    this.changeXPosition(xPosition);
}
```

C.

```
public void clickIt() {
    this.changeXPosition(100.0);
}
```

D.

```
public double click() {
    return this.changeXPosition(100.0);
}
```