CS100
Introduction to Programming

Lecture 12. Object-Oriented Programming: Inheritance

Learning objectives

- Understand the different object relationships
- Learn how to implement inheritance
- Understand & define variable/function access
- Learn about overloading

Outline

- Code Reuse
- Object Relationships
- Inheritance
  - What is Inherited
  - Handling Access
- Overriding

Code Reuse

- Important to successful coding

- Efficient
  - no need to reinvent the wheel
- Error free (more likely to be)
  - code has been previously used/test

Code Reuse Examples

- What are some ways we reuse code?
  - Functions
  - Classes
  - Inheritance – will be covered today

- Any specific examples?
  - calling accessor functions inside a constructor

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Refresher on Objects

- ***objects*** are what we call an ***instance*** of a ***class***

- For example:
  - **`Date`** is a class
  - **`today, helloween`**, etc. could be variables of type **`Date`**
  - We say that **`today`** and **`helloween`** are **`Date`** objects

Object Relationships

- Two types of object relationships

- The “is-a” relationship
  - inheritance

- The “has-a” relationship
  - composition
  - aggregation

} both are forms of association

Inheritance Relationship

a Car ***is-a*** Vehicle

- this is called ***inheritance***

Inheritance Relationship

a Car ***is-a*** Vehicle

- the Car class ***inherits*** from the Vehicle class

- Vehicle is the general class, or the ***parent class***
- Car is the specialized class, or ***child class***, that inherits from Vehicle

Inheritance Relationship Code

```
class Vehicle {
  public:
    // functions
  private:
    int    m_numAxles;
    int    m_numWheels;
    int    m_maxSpeed;
    double m_weight;
    // etc
} ;
```

all Vehicles have axles, wheels, a max speed, and a weight

Inheritance Relationship Code

```
class Car {









} ;
```

Inheritance Relationship Code

```
class Car: public Vehicle {




} ;
```

Car inherits from
the Vehicle class

Inheritance Relationship Code

```
class Car: public Vehicle {



};
```

Car inherits from the Vehicle class

don't forget the colon here!

Inheritance Relationship Code

```
class Car: public Vehicle {
  public:
    // functions
  private:
    int    m_numSeats;
    double m_MPG;
    string m_color;
    string m_fuelType;
    // etc
} ;
```

all Cars have a number of seats, a MPG value, a color, and a fuel type

Inheritance Relationship Code

```
class Car:
  public Vehicle { /*etc*/ };
class Plane:
  public Vehicle { /*etc*/ };
class SpaceShuttle:
  public Vehicle { /*etc*/ };
class BigRig:
  public Vehicle { /*etc*/ };
```

Composition Relationship

a Car ***has-a*** Chassis

- this is called ***composition***

Composition Relationship

a Car ***has-a*** Chassis

- the Car class ***contains*** an object of type Chassis

- a Chassis object is part of the Car class
- a Chassis cannot "live" out of context of a Car
  - if the Car is destroyed, the Chassis is also destroyed

Composition Relationship Code

```
class Chassis {
   public:
      //functions
   private:
      string m_material;
      double m_weight;
      double m_maxLoad;
      // etc
} ;
```

all Chassis have a material, a weight, and a maxLoad they can hold

Composition Relationship Code

```
class Chassis {
   public:
      //functions
   private:
      string m_material;
      double m_weight;
      double m_maxLoad;
      // etc
} ;
```

also, notice that there is no inheritance for the Chassis class

Composition Relationship Code

```
class Car: public Vehicle {
  public:
    //functions
  private:
    // member variables, etc.



} ;
```

Composition Relationship Code

```
class Car: public Vehicle {
  public:
    //functions
  private:
    // member variables, etc.

    // has-a (composition)
    Chassis m_chassis;
} ;
```

Aggregation Relationship

a Car ***has-a*** Driver

- this is called ***aggregation***

Aggregation Relationship

a Car ***has-a*** Driver

- the Car class is ***linked to*** an object of type Driver

- Driver class is not directly related to the Car class
- a Driver **can** live out of context of a Car
- a Driver must be “contained” in the Car object via a pointer to a Driver object

Aggregation Relationship Code

```
class Driver: public Person {
  public:
    // functions
  private:
    Date   m_licenseExpire;
    string m_licenseType;
    // etc
} ;
```

Driver itself is a child class of Person

Driver inherits all of Person’s member variables (Date m_age, string m_name, etc.) so they aren’t included in the Driver child class

Aggregation Relationship Code

```
class Car: public Vehicle {
   public:
      //functions
   private:
      // member variables, etc.



} ;
```

Aggregation Relationship Code

```
class Car: public Vehicle {
   public:
      //functions
   private:
      // member variables, etc.

      // has-a (aggregation)
      Person *m_driver;
} ;
```

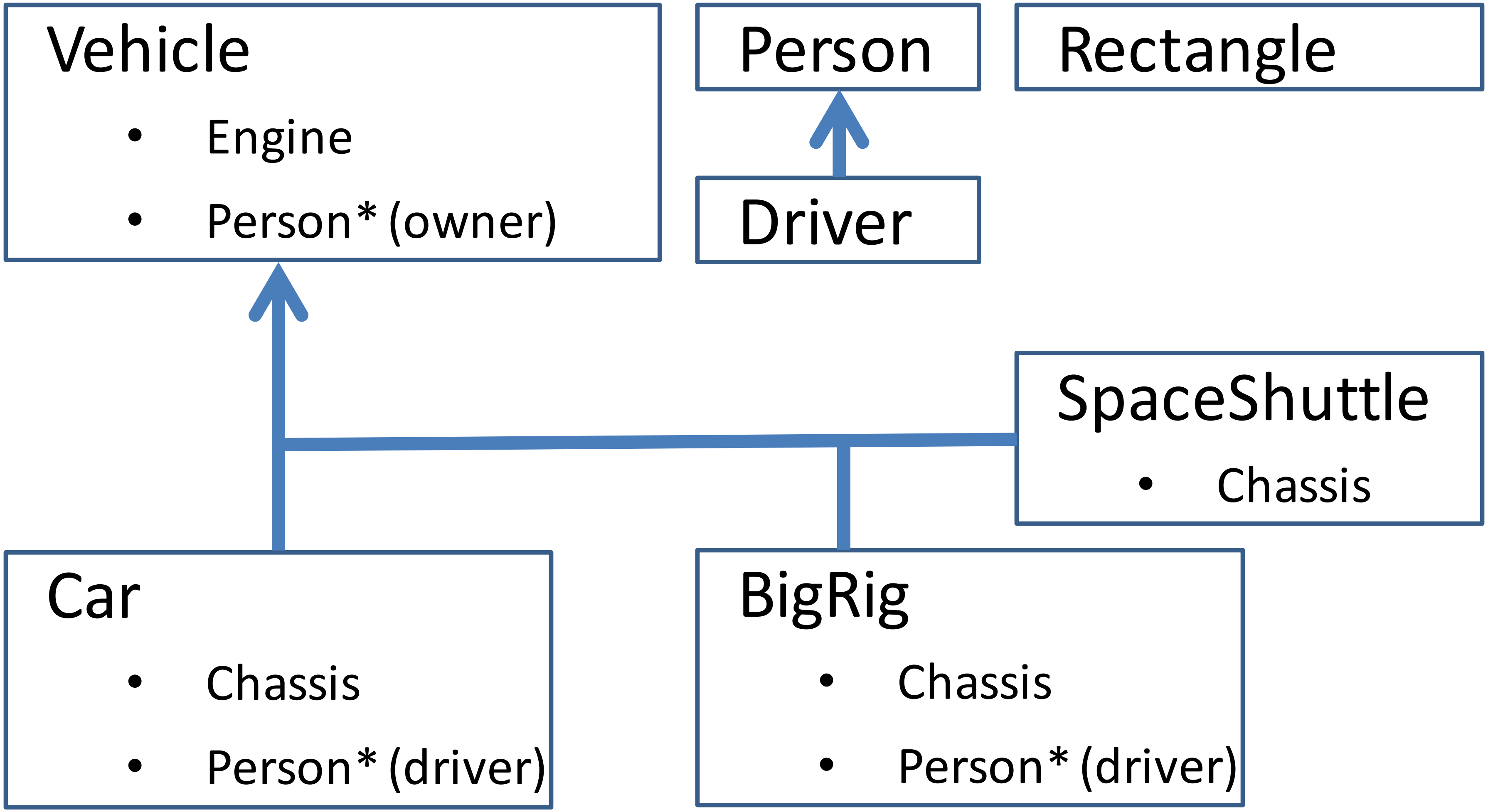
Visualizing Object Relationships

- on paper, draw a representation of how the following objects relate to each other
- make sure the type of relationship is clear

- Car
- Vehicle
- BigRig
- Rectangle
- SpaceShuttle

- Engine
- Driver
- Person
- Owner
- Chassis

Visualizing Object Relationships



Vehicle

- Engine
- Person* (owner)

Person

Rectangle

Driver

SpaceShuttle

- Chassis

Car

- Chassis
- Person* (driver)

BigRig

- Chassis
- Person* (driver)

Outline

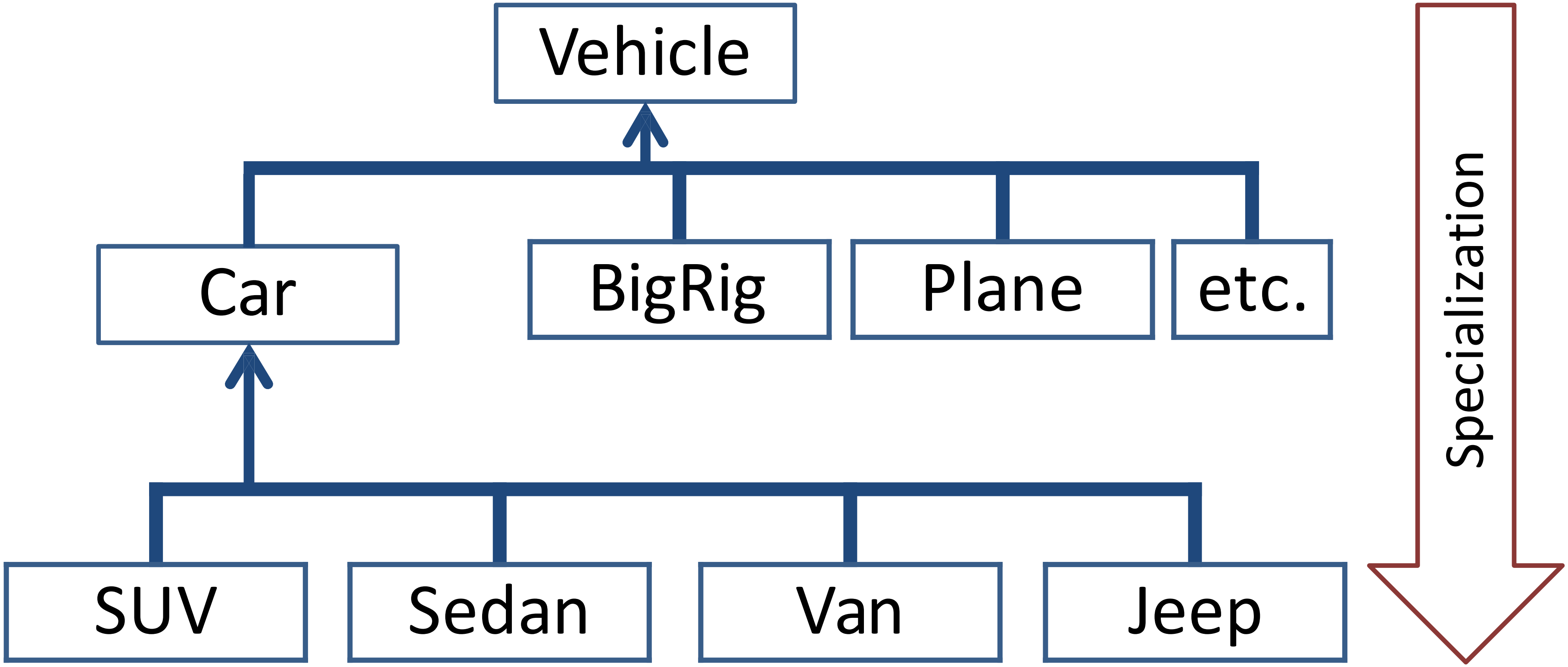
- Code Reuse
- Object Relationships
- Inheritance
  - What is Inherited
  - Handling Access
- Overriding

Inheritance Access Specifiers

- inheritance can be done via:
  public, ***private***, or ***protected***
  - we're going to focus exclusively on ***public***

- you can also have multiple inheritance
  - where a child class has more than one parent
  - we won't be covering this

Hierarchy Example



Hierarchy Vocabulary

- **more general class** (e.g., Vehicle) can be called:
  - parent class
  - base class
  - superclass
- **more specialized class** (e.g., Car) can be called:
  - child class
  - derived class
  - subclass

Hierarchy Details

- parent class contains all it has in common with its child classes (less specialized)
  - Vehicle has a maximum speed, a weight, etc. because all vehicles have these

- member variables and functions of the parent class are inherited by **all** of its child classes

Hierarchy Details

- child classes can use, extend, or replace the parent class behaviors

Hierarchy Details

- child classes can **use**, extend, or replace the parent class behaviors

- use
  - the child class takes advantage of the parent class behaviors exactly as they are
    - like the mutators and accessors from the parent class

Hierarchy Details

- child classes can use, **extend**, or replace the parent class behaviors

- extend
  - the child class creates entirely new behaviors
    - a **`RepaintCar()`** function for the Car child class
    - mutators/accessors for new member variables

Hierarchy Details

- child classes can use, extend, or **replace** the parent class behaviors

- replace
  - child class overrides parent class's behaviors
    - (we'll cover this later today)

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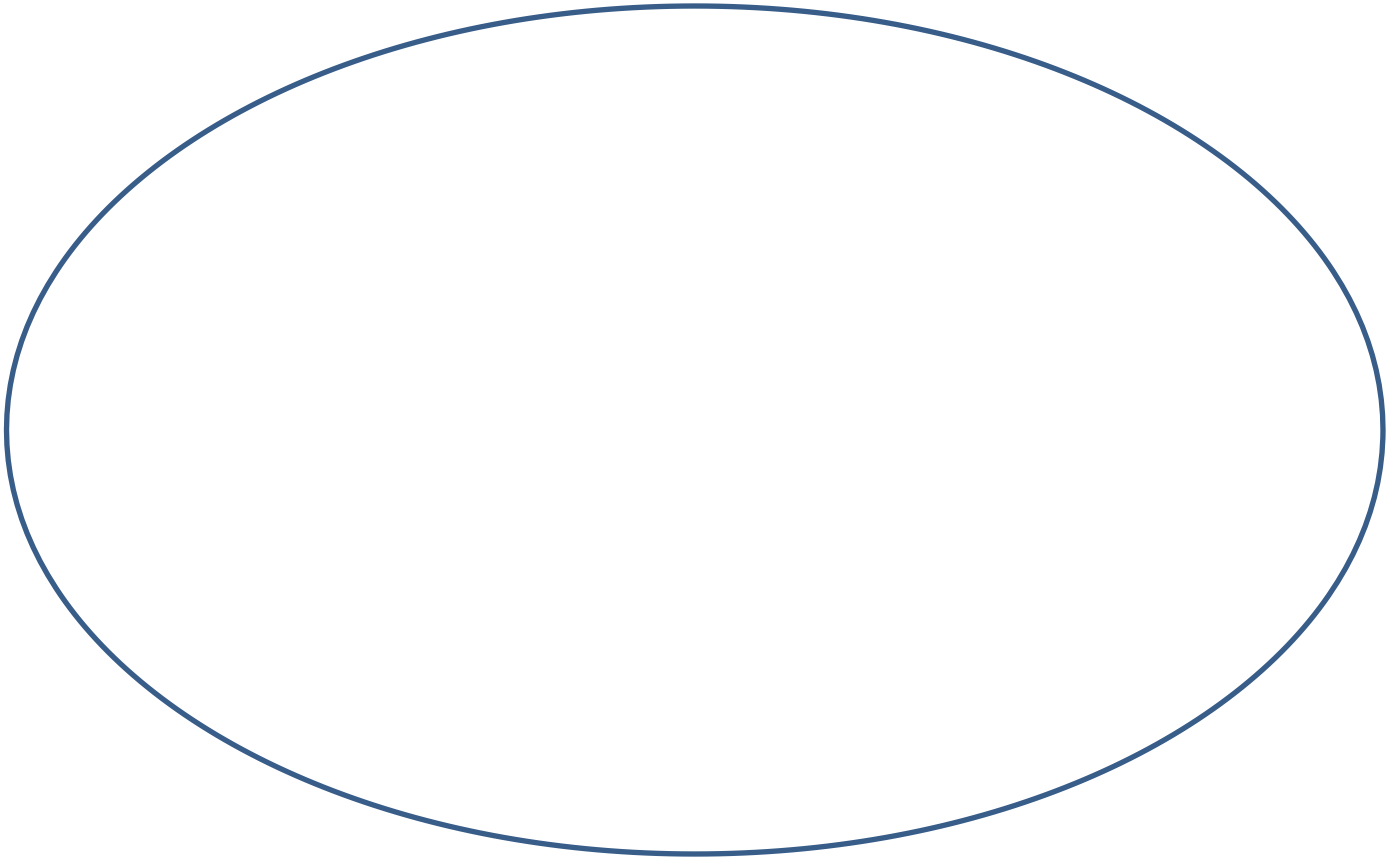
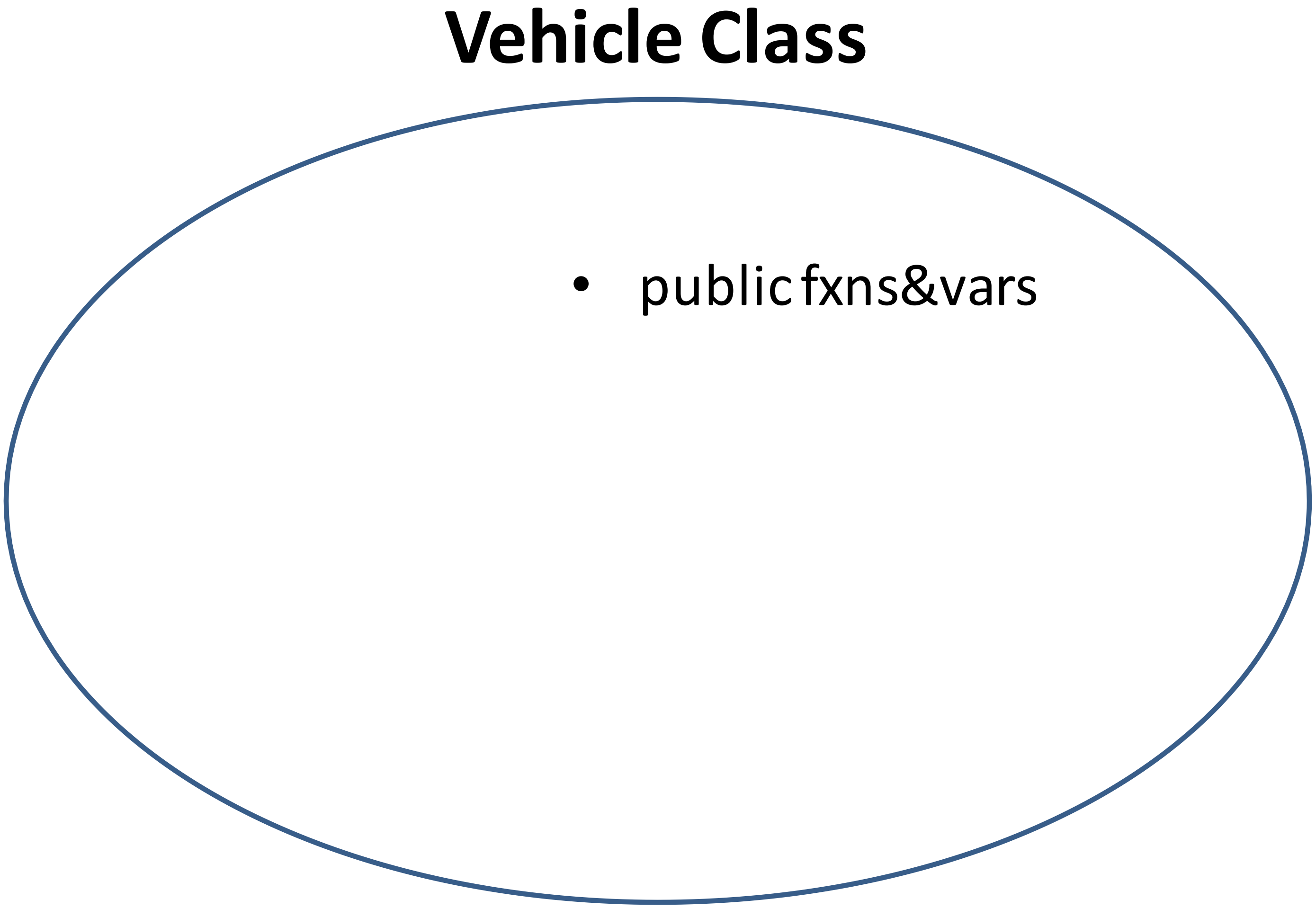
What is Inherited

Vehicle Class



What is Inherited

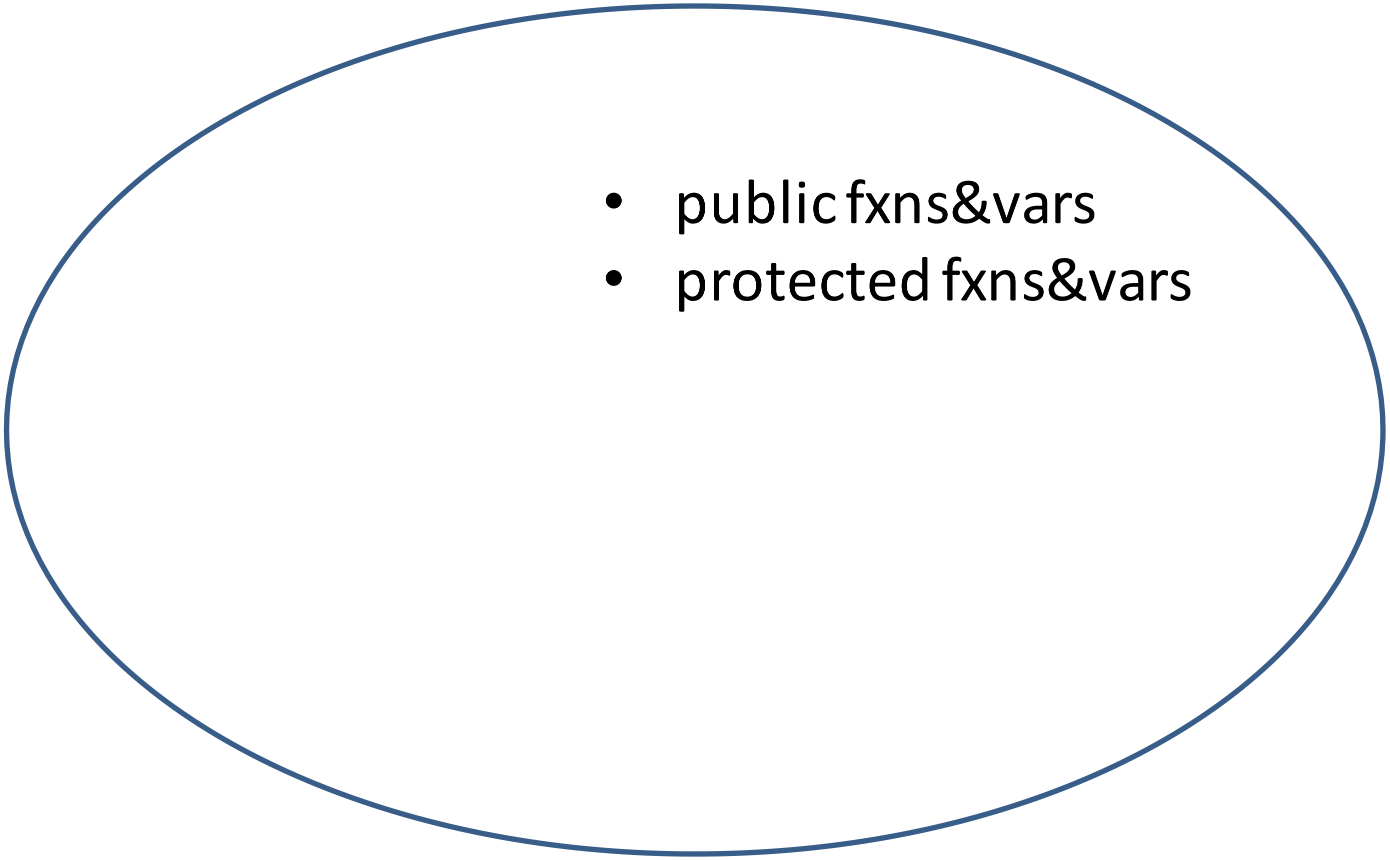


Vehicle Class

- public fxns&vars

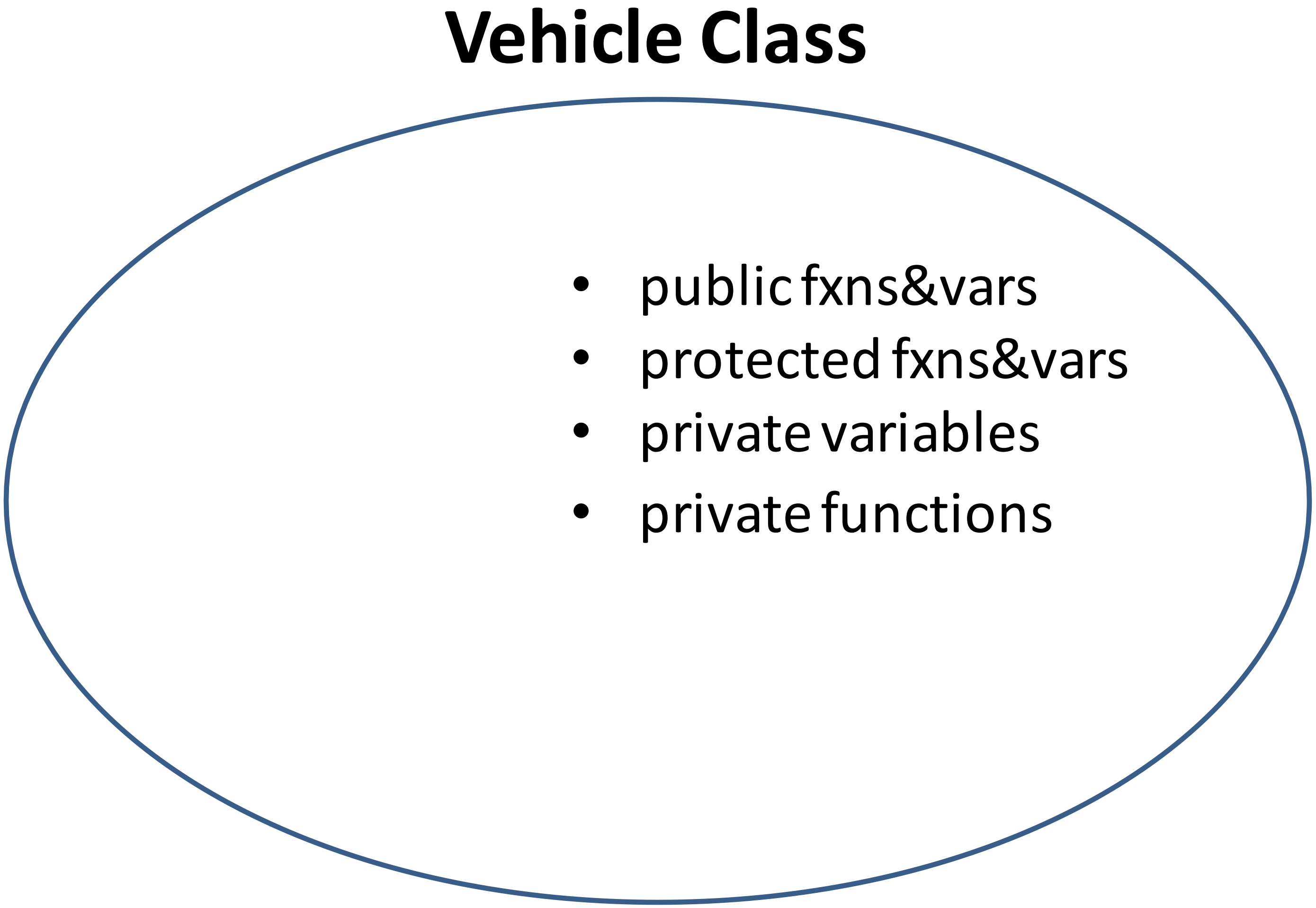
What is Inherited

Vehicle Class



- public fxns&vars
- protected fxns&vars

What is Inherited

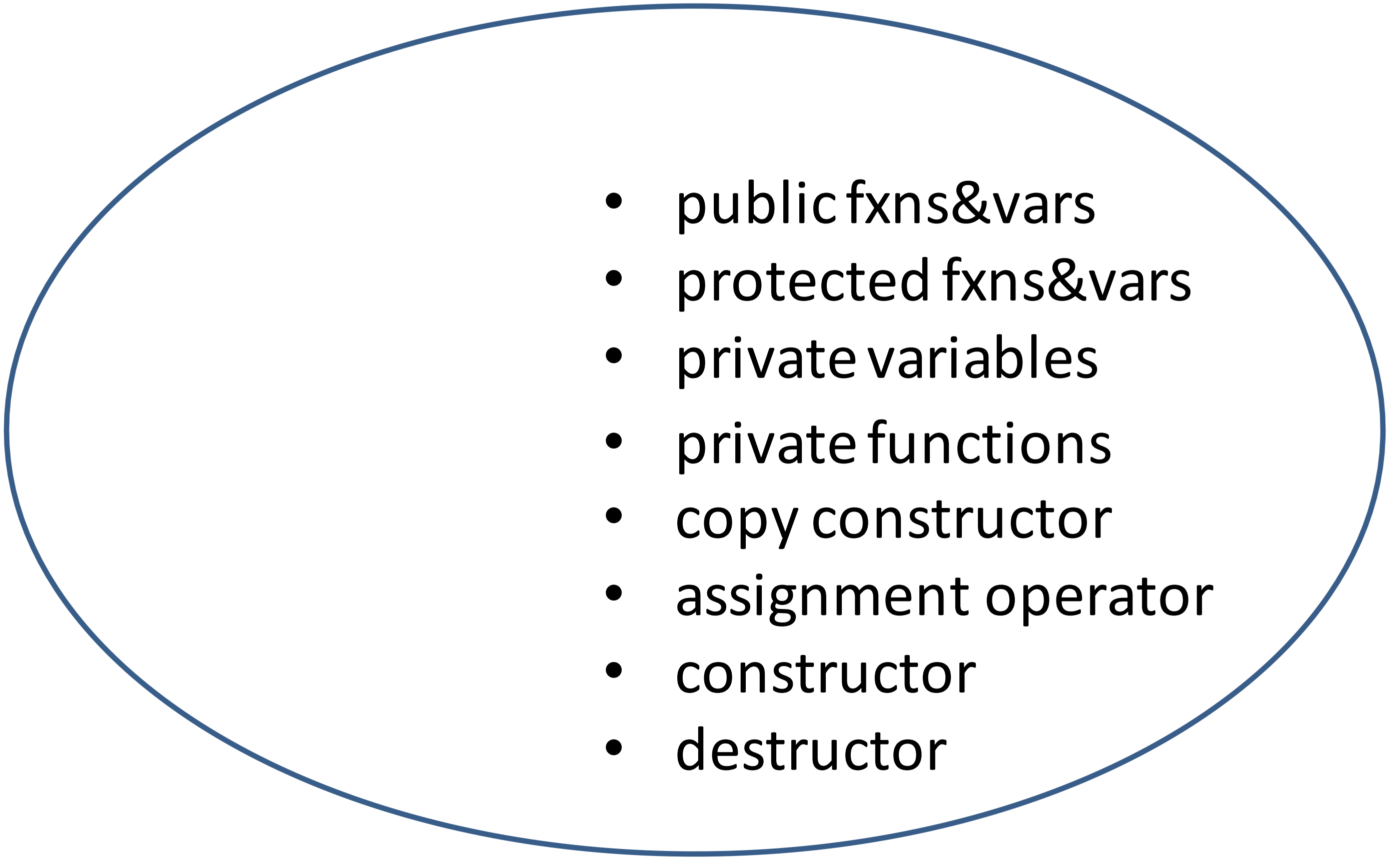


Vehicle Class

- public fxns&vars
- protected fxns&vars
- private variables
- private functions

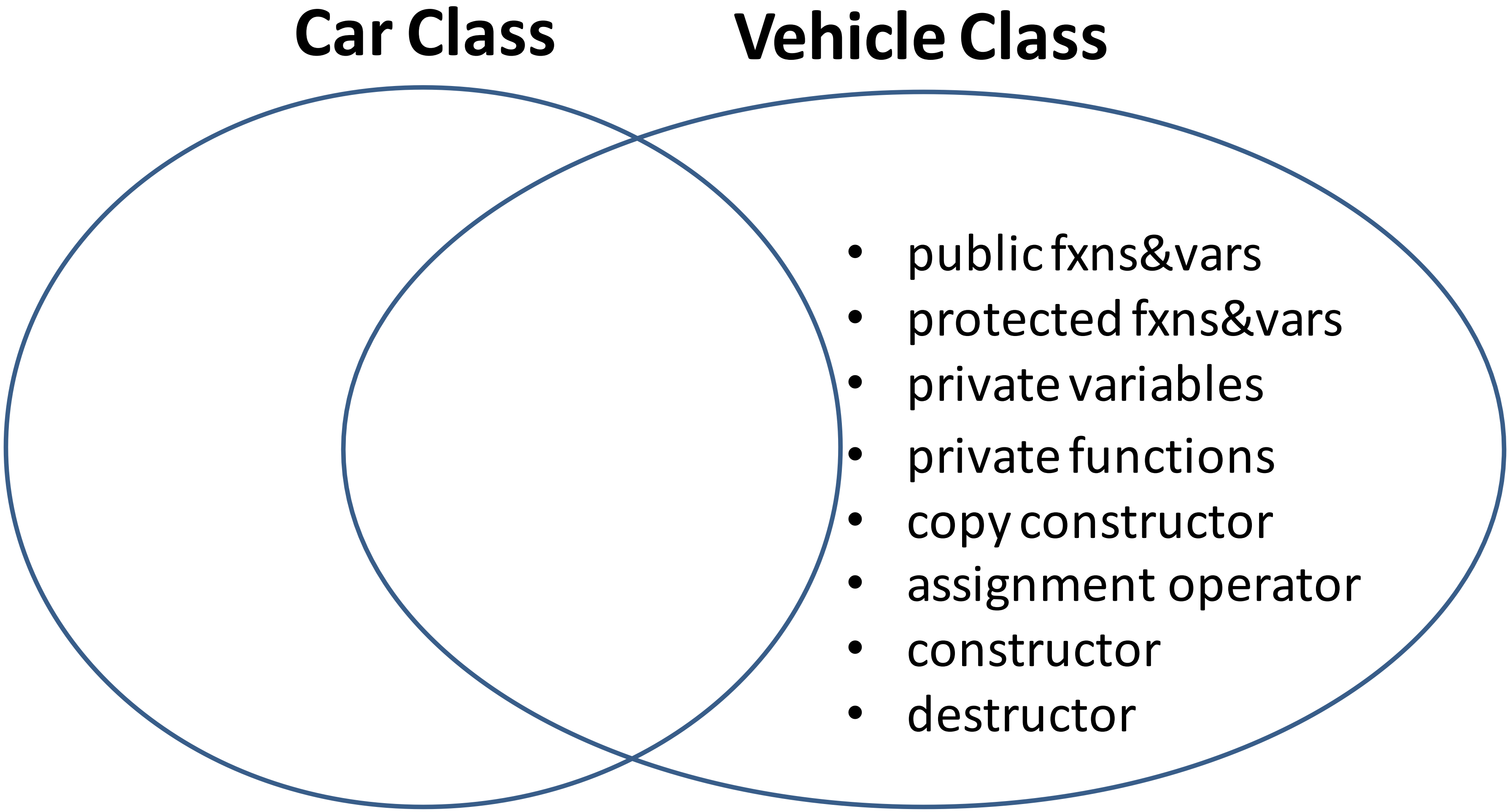
What is Inherited

Vehicle Class



- public fxns&vars
- protected fxns&vars
- private variables
- private functions
- copy constructor
- assignment operator
- constructor
- destructor

What is Inherited

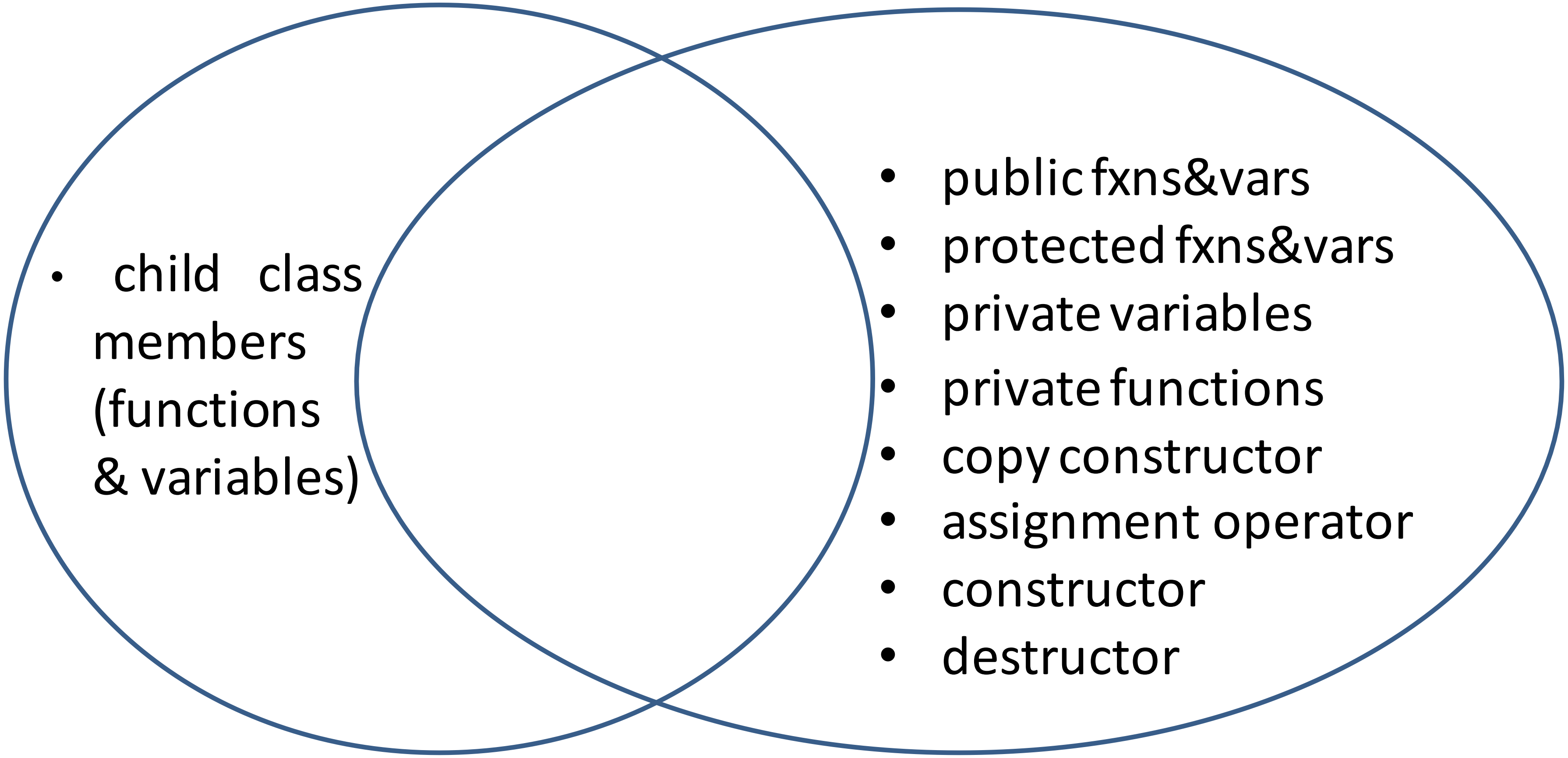


Car Class

Vehicle Class

- public fxns&vars
- protected fxns&vars
- private variables
- private functions
- copy constructor
- assignment operator
- constructor
- destructor

What is Inherited



Car Class

- child class members (functions & variables)

Vehicle Class

- public fxns&vars
- protected fxns&vars
- private variables
- private functions
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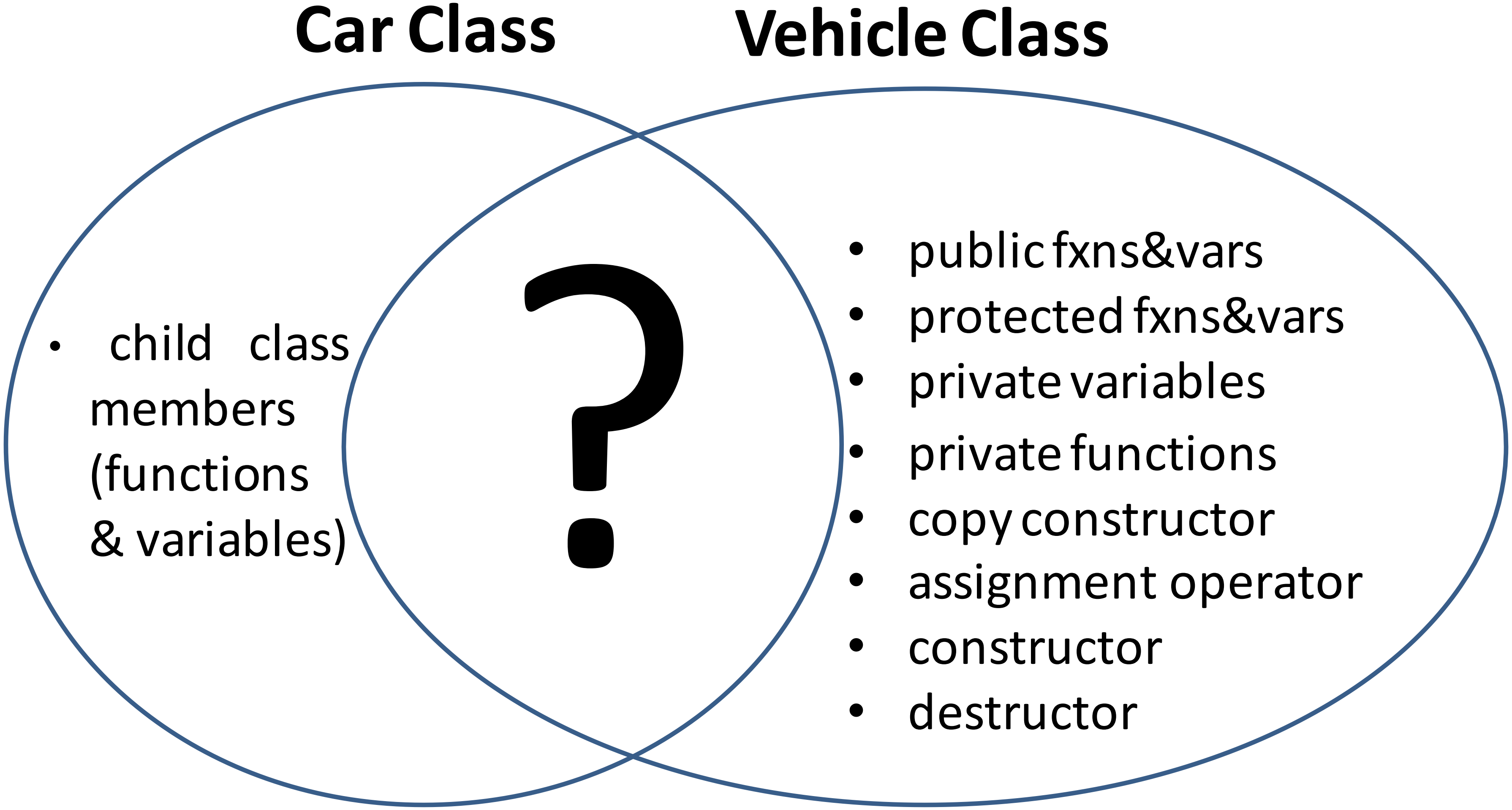
What is Inherited



Car Class

Vehicle Class

- child class members (functions & variables)

?

- public fxns&vars
- protected fxns&vars
- private variables
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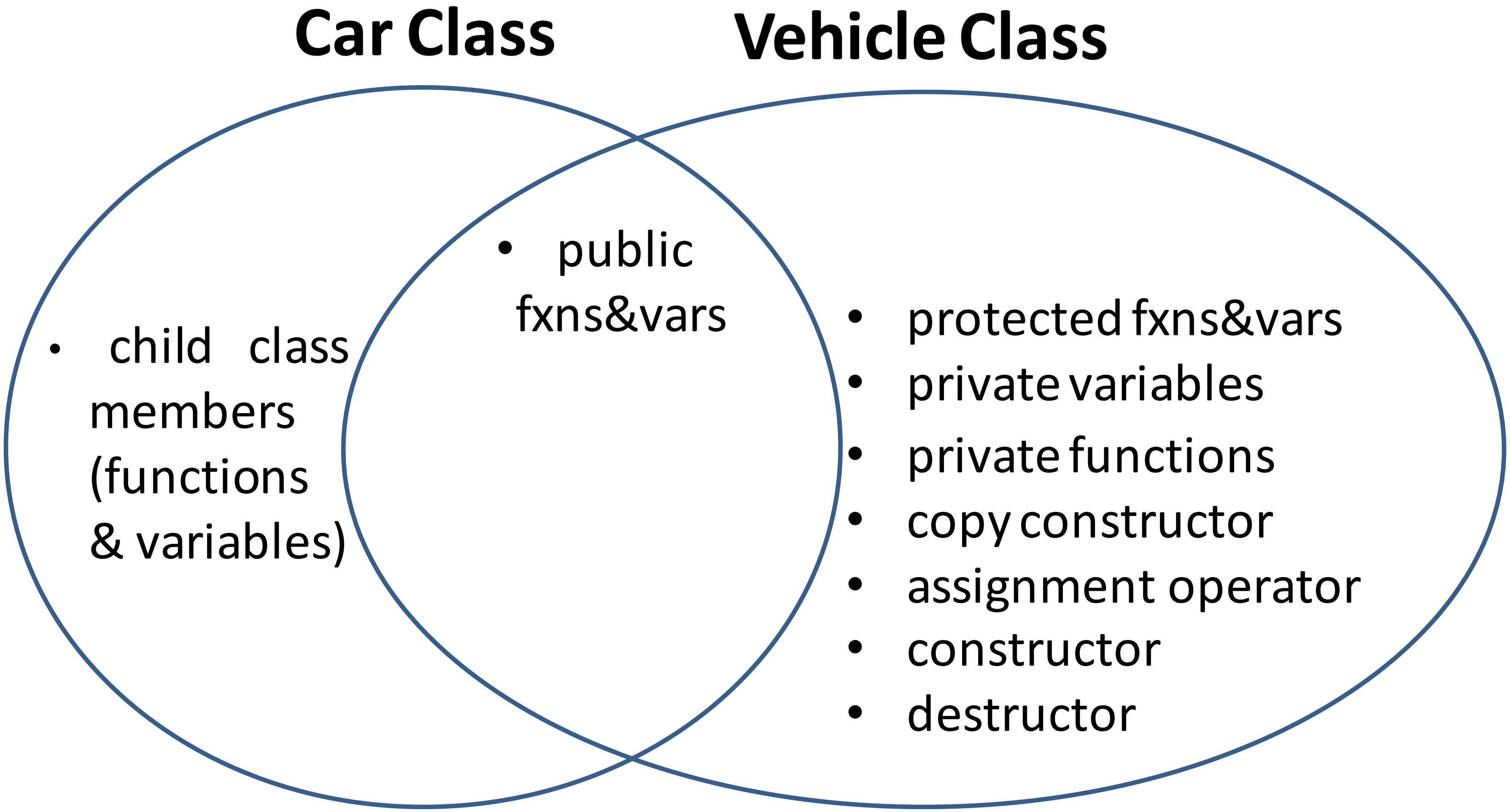
What is Inherited



Car Class

Vehicle Class

- child class members (functions & variables)

- public fxns&vars

- protected fxns&vars
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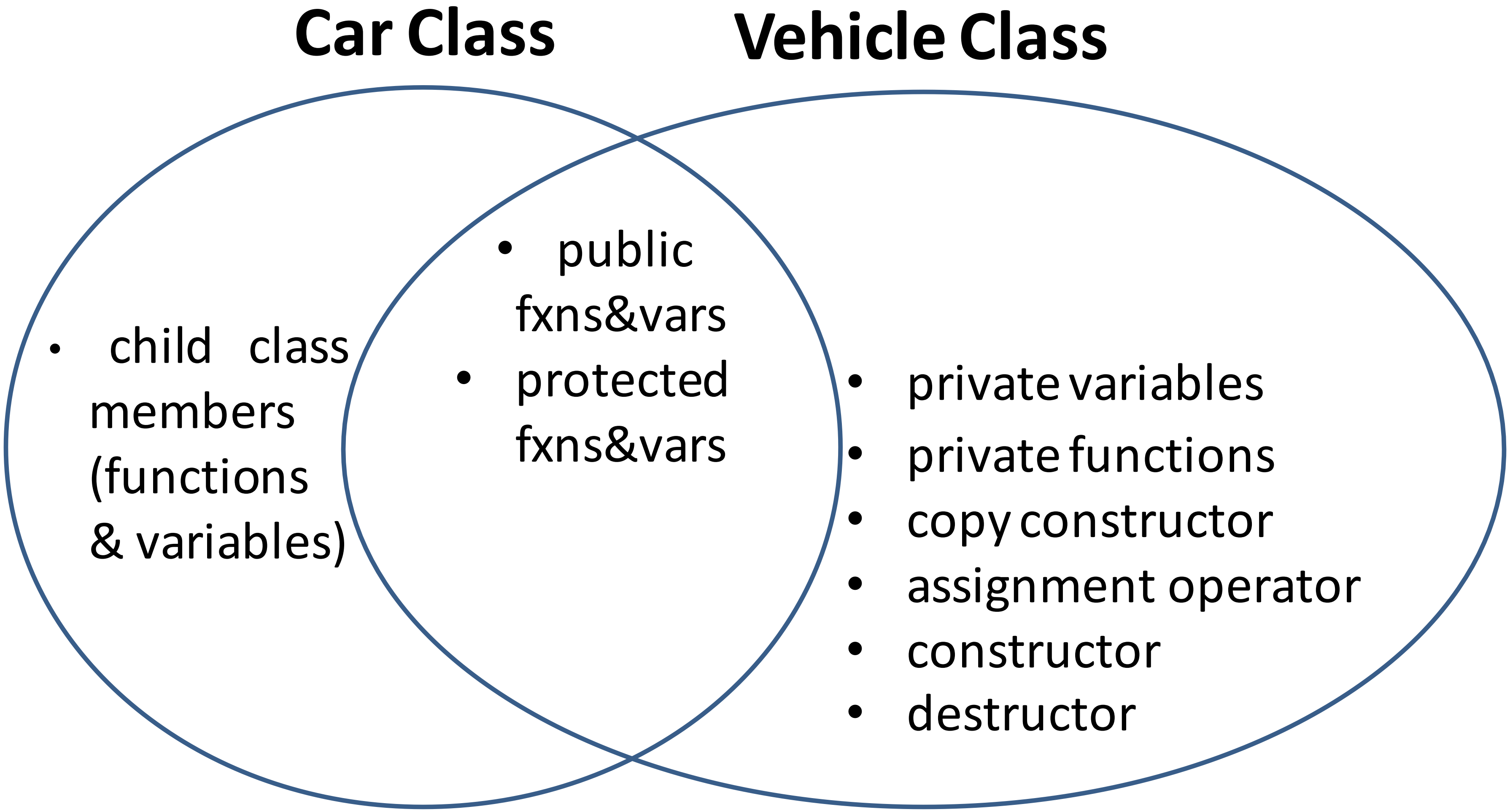
What is Inherited



Car Class

Vehicle Class

- child class members (functions & variables)

- public fxns&vars
- protected fxns&vars

- private variables
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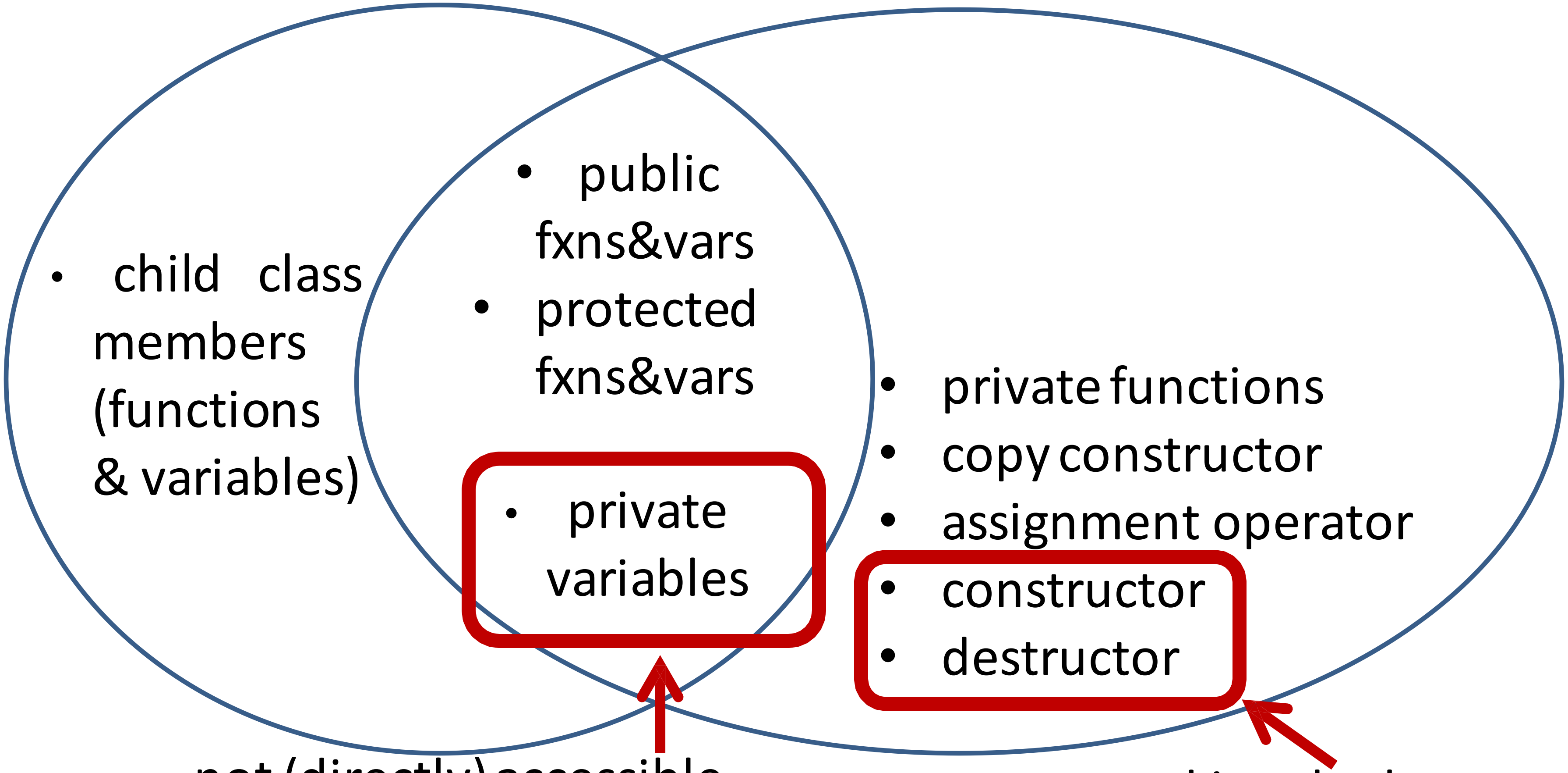
What is Inherited



Car Class

Vehicle Class

- child class members (functions & variables)

- public fxns&vars
- protected fxns&vars

- private variables

- private functions
- copy constructor
- assignment operator

- constructor
- destructor

not (directly) accessible by Car objects

can access and invoke, but are not directly inherited

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Handling Access

- child class has access to parent class's:
  - public member variables/functions
  - protected member variables/functions
  - but *not* private member variables/functions
- how should we set the access modifier for parent member variables we want the child class to be able to access?

Handling Access

- we should <u>not</u> make these variables protected!

- leave them private!
- instead, child class uses protected functions when interacting with parent variables
  - mutators
  - accessors

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Specialization

- child classes are meant to be more specialized than parent classes
  - adding new member functions
  - adding new member variables

- child classes can also specialize by ***overriding*** parent class member functions
  - child class uses **exact same function signature**

Overloading vs Overriding

- ***overloading***
  - use the same function name, but with different parameters for each overloaded implementation

- ***overriding***
  - use the same function name and parameters, but with a different implementation
  - child class method “hides” parent class method
  - **only possible by using inheritance**

Overriding Examples

- For these examples, the Vehicle class now contains these public functions:

```
void Upgrade();
void PrintSpecs();
void Move(double distance);
```

Overriding Examples

- For these examples, the Vehicle class now contains these public functions:

```
void Upgrade();
void PrintSpecs();
void Move(double distance);
```

- Car class inherits all of these public functions
  - it can therefore override them

Basic Overriding Example

- Car class overrides Upgrade()

```
void Car::Upgrade()
{
  // entirely new Car-only code
}
```

- when Upgrade() is called on a object of type Car, what happens?

Basic Overriding Example

- Car class overrides Upgrade()

```
void Car::Upgrade()
{
   // entirely new Car-only code
}
```

- when Upgrade() is called on a object of type Car, the Car::Upgrade() function is invoked

Overriding (and Calling) Example

- Car class overrides **and calls** PrintSpecs()

```
void Car::PrintSpecs()
{
   Vehicle::PrintSpecs();
   // additional Car-only code
}
```

- can explicitly call a parent’s original function by using the scope resolution operator

Attempted Overloading Example

- Car class attempts to **overload** the function Move(double distance) with new parameters

```
void Car::Move(double distance,
               double avgSpeed)
{
   // new overloaded Car-only code
}
```

- but this does something we weren’t expecting!

Precedence

- **overriding takes precedence over overloading**
  - instead of *overloading* the Move() function, the compiler assumes we are trying to *override* it

- declaring `Car::Move(2 parameters)`
- overrides `Vehicle::Move(1 parameter)`

- we no longer have access to the original `Move()` function from the Vehicle class

Overloading in Child Class

- to overload, we must have both original and overloaded functions in child class

```
void Car::Move(double distance);
void Car::Move(double distance,
               double avgSpeed);
```

- the “original” one parameter function can then explicitly call parent function

During Recitation

- Complex inheritance!