Creative Software Design

8 – Inheritance, Const & Class

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Outline

- Brief intro to "Fundamental Principles of Object-Oriented Programming"
- Inheritance
  - Concept
  - Overriding
  - Constructor & Destructor with Inheritance
  - Member initializer list with Inheritance
  - Multiple Inheritance
- Const & Class

Fundamental Principles of Object-Oriented Programming

- Encapsulation (already covered in 6 - Class)
  - Binding the data with the code that manipulates it into a single unit
  - → Hiding details of the unit (data hiding).

- Inheritance (Today’s topic)
  - Creating a class based on another class by "inheriting" its properties and behaviors (attributes and methods, or member variables and member functions).

- Polymorphism (Next lecture)
  - The ability to create a variable, a function, or an object that has more than one form.

- Abstraction (closely related to polymorphism)
  - The principle of generalization - from a specific instance to a more generalized concept.

Inheritance

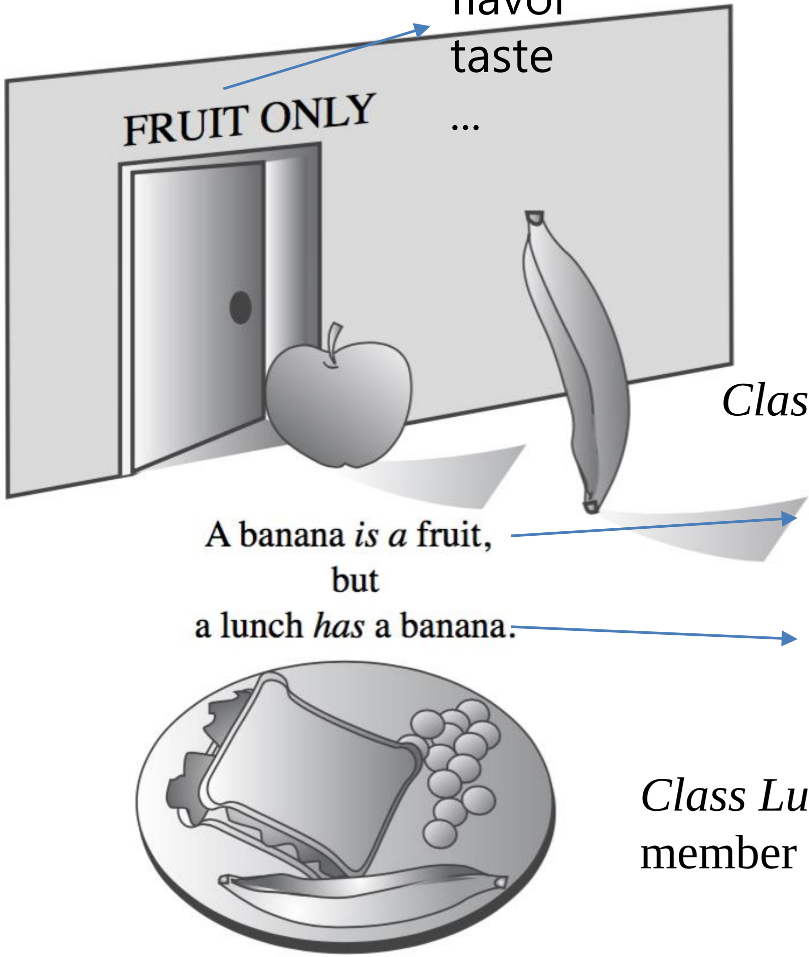
- Building a class on the top of an existing class.

- The goal is to
  - reuse the code for similar functionalities
  - and write new code only for additional functionalities.

- This allows you to establish **relationships** between classes.

Inheritance: is-a relationship

color
flavor
taste
…



Class Banana inherits from *class Fruit.*

Inheritance: is-a relationship

Composition: has-a relationship

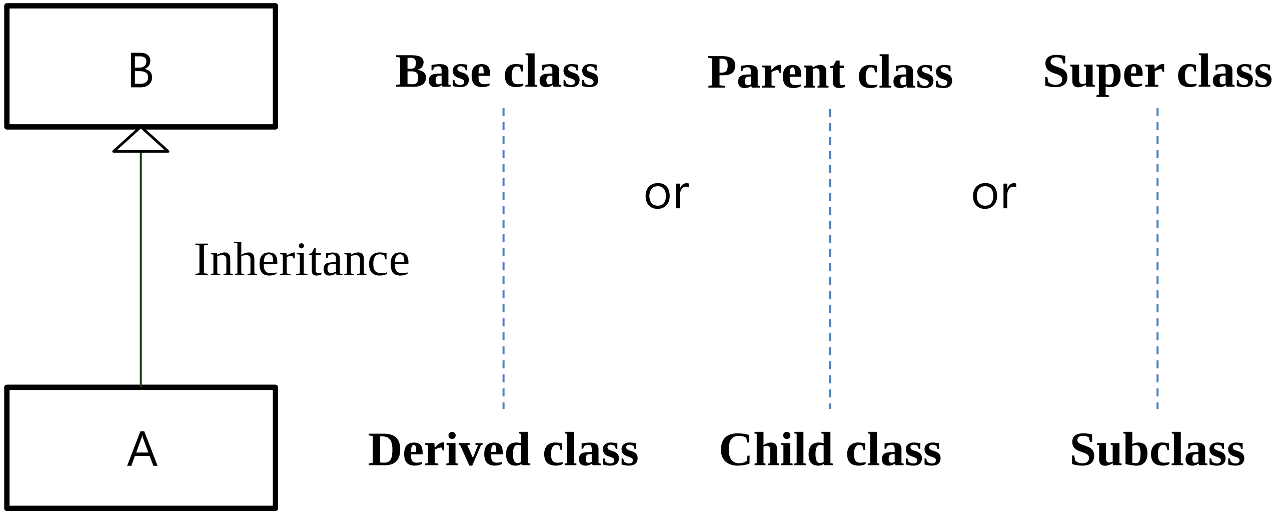
Class Lunch has a *class Banana* instance as a member variable.

Inheritance: is-a relationship

- "is-a" relationship: use (public) inheritance when "A" is a "B".
  - A car is a vehicle.
    A truck is a vehicle.
    A cart is a vehicle.
    …
  - A student is a person.
    A professor is a person.
    …
  - A person is an animal.
    A dog is an animal.
    …

Inheritance

- If a class A inherits from another class B,
  - Class A implicitly "has" the member variables and functions of class B.
  - Class A can have additional member variables and functions.

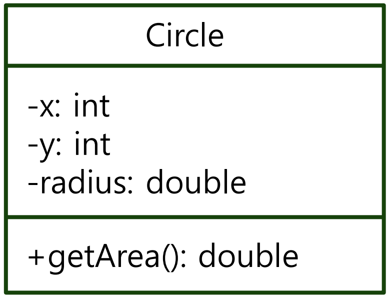


(UML class diagram)

```
class A : public B
{
   ...
};
```

UML Class Diagram Example

Unified Modeling Language (UML): for visualizing the design of a software system.



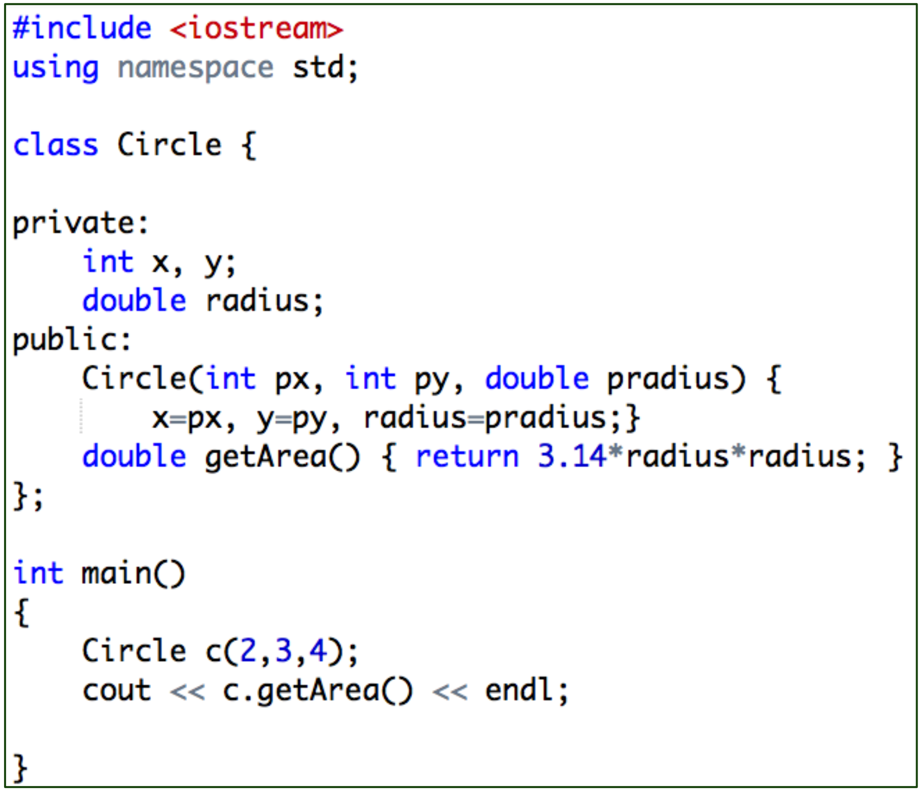
Circle

-x: int
-y: int
-radius: double

+getArea(): double

+: public
-: private
#: protected

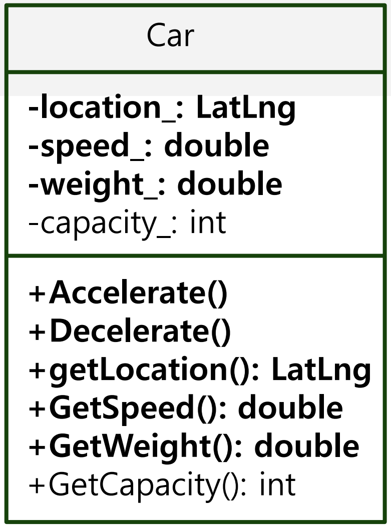
variable: data type
method(parameter): return type



```
#include <iostream>
using namespace std;

class Circle {

private:
    int x, y;
    double radius;
public:
    Circle(int px, int py, double pradius) {
        x=px, y=py, radius=pradius;}
    double getArea() { return 3.14*radius*radius; }
};

int main()
{
    Circle c(2,3,4);
    cout << c.getArea() << endl;

}
```

An Inheritance Example

```
class Car {
 public:
  Car() {}
  void Accelerate();
  void Decelerate();
  LatLng GetLocation();
  double GetSpeed();
  double GetWeight();
  int GetCapacity();
 private:
  LatLng location_;
  double speed_;
  double weight_;
  int capacity_;
};
```

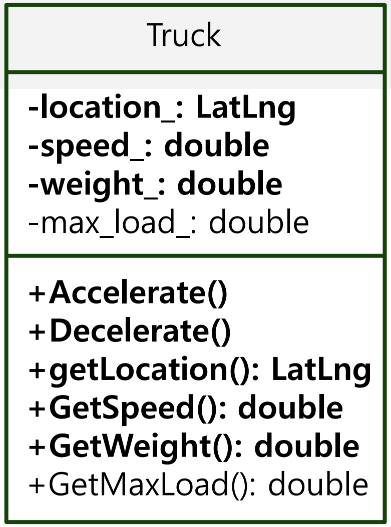


Car

-location_: LatLng
-speed_: double
-weight_: double
-capacity_: int

+Accelerate()
+Decelerate()
+getLocation(): LatLng
+GetSpeed(): double
+GetWeight(): double
+GetCapacity(): int

```
class Truck {
 public:
  Truck() {}
  void Accelerate();
  void Decelerate();
  LatLng GetLocation();
  double GetSpeed();
  double GetWeight();
  double GetMaxLoad();
 private:
  LatLng location_;
  double speed_;
  double weight_;
  double max_load_;
};
```



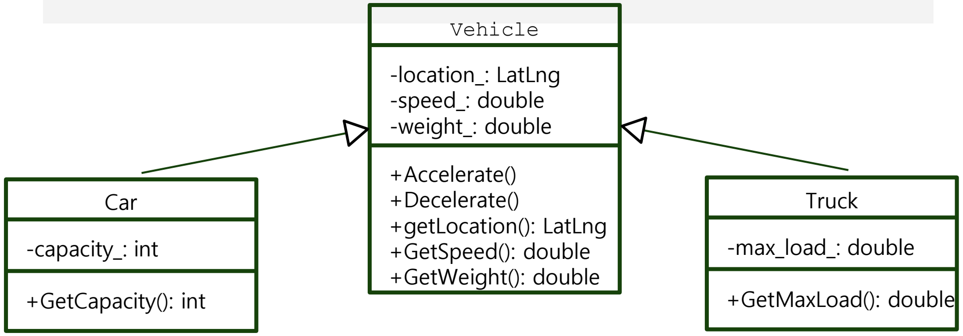
Truck

-location_: LatLng
-speed_: double
-weight_: double
-max_load_: double

+Accelerate()
+Decelerate()
+getLocation(): LatLng
+GetSpeed(): double
+GetWeight(): double
+GetMaxLoad(): double

An Inheritance Example

```
// Vehicle class.

class Vehicle {
 public:
  Vehicle() {}
  void Accelerate();
  void Decelerate();

  LatLng GetLocation();
  double GetSpeed();
  double GetWeight();

 private:
  LatLng location_;
  double speed_;
  double weight_;
};
```



Vehicle

-location_: LatLng
-speed_: double
-weight_: double

+Accelerate()
+Decelerate()
+getLocation(): LatLng
+GetSpeed(): double
+GetWeight(): double

Car

-capacity_: int

+GetCapacity(): int

Truck

-max_load_: double

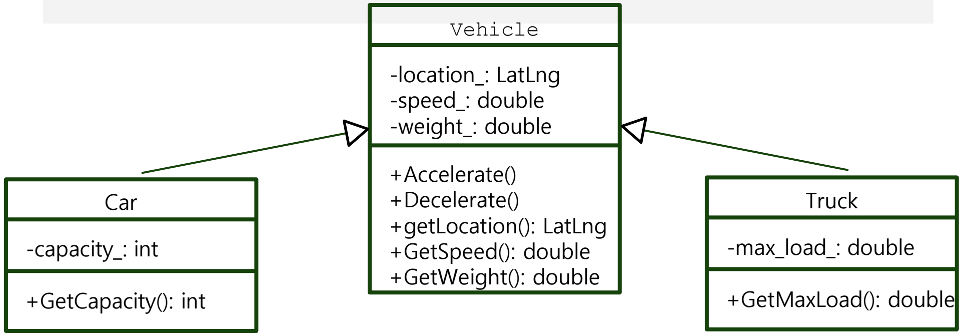
+GetMaxLoad(): double

```
// Car class.

class Car : public Vehicle {
 public:
  Car() : Vehicle() {}

  int GetCapacity();

 private:
  int capacity_;
};
```

```
// Truck class.

class Truck : public Vehicle {
 public:
  Truck() : Vehicle() {}

  double GetMaxLoad();

 private:
  double max_load_;
};
```

An Inheritance Example

```
// Vehicle class.

class Vehicle {
 public:
  Vehicle() {}
  void Accelerate();
  void Decelerate();

  LatLng GetLocation();
  double GetSpeed();
  double GetWeight();

 private:
  LatLng location_;
  double speed_;
  double weight_;
};
```



Vehicle

-location_: LatLng
-speed_: double
-weight_: double

+Accelerate()
+Decelerate()
+getLocation(): LatLng
+GetSpeed(): double
+GetWeight(): double

Car

-capacity_: int

+GetCapacity(): int

Truck

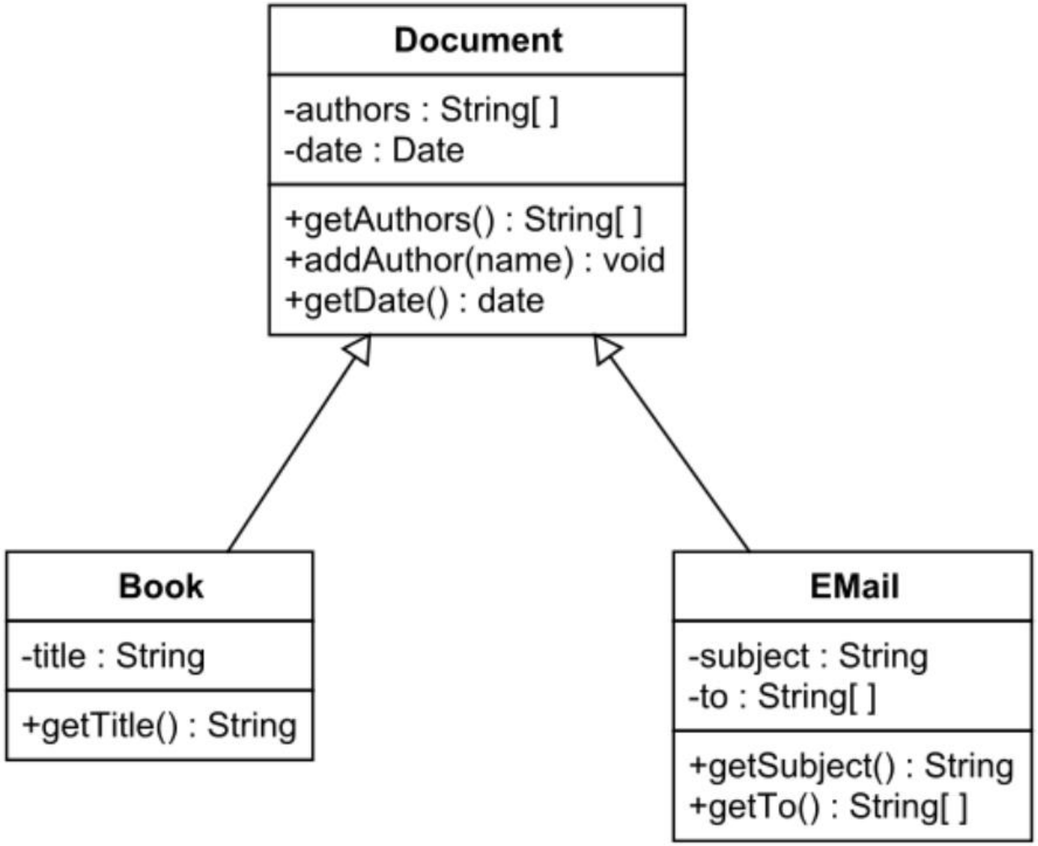
-max_load_: double

+GetMaxLoad(): double

```
// Car class.

class Car : public Vehicle {
 public:
  Car() : Vehicle() {}

  int GetCapacity();

 private:
  int capacity_;
};
```

```
// Main routine.

int main() {
  Car car;
  cout << car.GetCapacity() << endl;
  cout << car.GetSpeed() << endl;
  cout << car.GetWeight() << endl;
  return 0;
}
```

Another inheritance example



Document

-authors : String[ ]
-date : Date

+getAuthors() : String[ ]
+addAuthor(name) : void
+getDate() : date

Book

-title : String

+getTitle() : String

EMail

-subject : String
-to : String[ ]

+getSubject() : String
+getTo() : String[ ]

Quiz 1

- Go to https://www.slido.com/
- Join #**csd-ys**
- Click "Polls"

- Submit your answer in the following format:
  - **Student ID: Your answer**
  - **e.g. 2022123456: 4)**

- Note that your quiz answer must be submitted **in the above format** to receive a quiz score!

Overriding vs. Overloading

- Function overloading (함수 중복정의)
  - provides multiple definitions of function by changing signatures (i.e. changing the number, order, or data type of parameters but leaving the function name the same)
  - has nothing to do with inheritance
  - should be used in the same scope

```
int print(int a) { … }

int print(int a, int b) { … }
```

- **Function overriding (함수 재정의)**
  - **Redefinition of base class function** in the derived class with same signatures

Overriding Member Function

- You can override a member function to provide a custom functionality of the derived class.

- Redefine a member function with the same name as the inherited functio n.
  - All ancestor's member functions with the same name will be occluded.
  - To access the ancestor's member functions, use `Ancestor::MemberFunction()`.

An example of overriding

```cpp
// Vehicle class.

class Vehicle {
 public:
  Vehicle() {}
  void Accelerate();
  void Decelerate();

  LatLng GetLocation();
  double GetSpeed();
  double GetWeight();

 private:
  LatLng location_;
  double speed_;
  double weight_;
};
```

```cpp
// Car class.
class Car : public Vehicle {
 public:
  Car() : Vehicle() {}

  int GetCapacity();

  // Override the parent's GetWeight().
  double GetWeight() {
    return Vehicle::GetWeight()+passenger_weight_;
  }
 private:
  int capacity_;
  double passenger_weight_;
};
```

```cpp
// Main routine.

int main() {
  Car car;
  cout << car.GetCapacity() << endl;
  cout << car.GetSpeed() << endl;
  cout << car.GetWeight() << endl;
  return 0;
}
```

An example of overriding

```
// Vehicle class.

class Vehicle {
 public:
  Vehicle() {}
  void Accelerate();
  void Decelerate();

  LatLng GetLocation();
  double GetSpeed();
  double GetWeight();

 private:
  LatLng location_;
  double speed_;
  double weight_;
};
```

```
// Car class.
class Car : public Vehicle {
 public:
  Car() : Vehicle() {}

  int GetCapacity();

  // Override the parent's GetWeight().
  double GetWeight() {
    return Vehicle::GetWeight()+passenger_weight_;
  }              =weight_?
 private:
  int capacity_;
  double passenger_weight_;
};
```

```
// Main routine.

int main() {
  Car car;
  cout << car.GetCapacity() << endl;
  cout << car.GetSpeed() << endl;
  cout << car.GetWeight() << endl;
  return 0;
}
```

An example of overriding

```
// Vehicle class.

class Vehicle {
 public:
  Vehicle() {}
  void Accelerate();
  void Decelerate();

  LatLng GetLocation();
  double GetSpeed();
  double GetWeight();

 protected:
  LatLng location_;
  double speed_;
  double weight_;
};
```

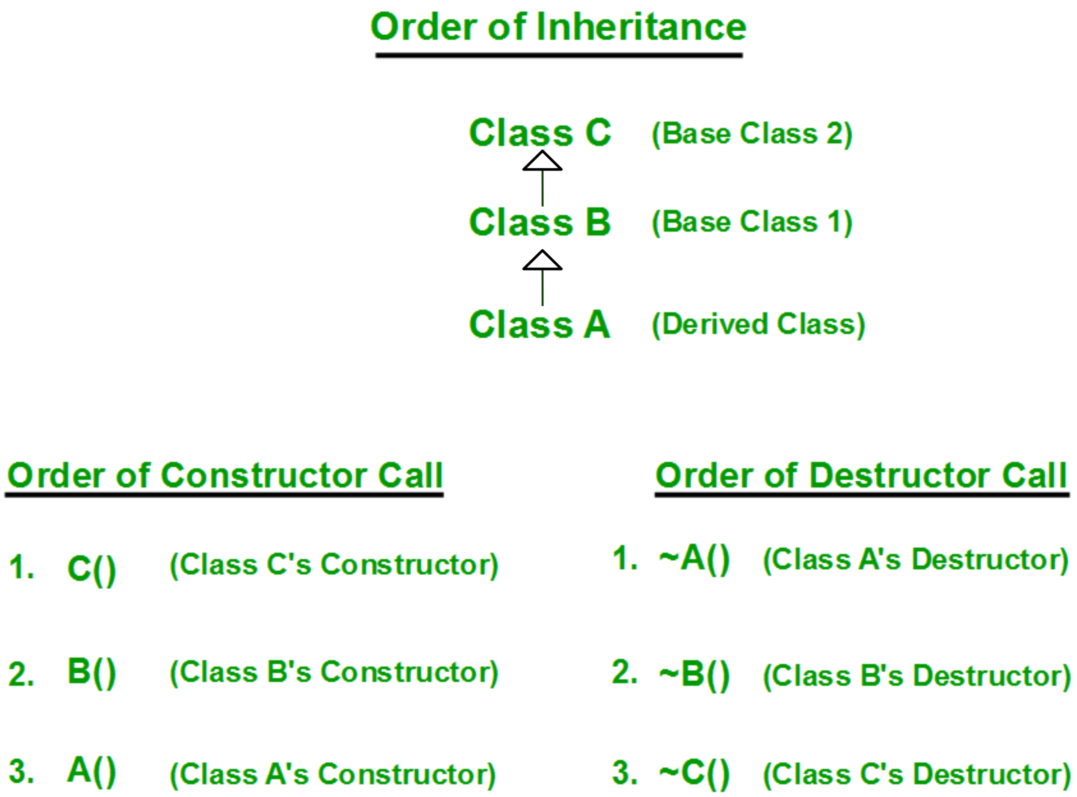
public: everyone can access.
private: only its member functions can access.
protected: its member functions and the member functions of descendant classes can access.

```
// Car class.
class Car : public Vehicle {
 public:
  Car() : Vehicle() {}

  int GetCapacity();
  // Override the parent's GetWeight().
  double GetWeight() {
    return weight_ + passenger_weight_;
  }
 private:
  int capacity_;
  double passenger_weight_;
};
```

```
// Main routine.
int main() {
  Car car;
  cout << car.GetCapacity() << endl;
  cout << car.GetSpeed() << endl;
  cout << car.GetWeight() << endl;
  return 0;
}
```

Constructor & Destructor with Inheritance

- Constructor and destructor call order:
  - Constructors are called from base class to derived class.
  - Destructors are called in reverse order.



Order of Inheritance

Class C (Base Class 2)

Class B (Base Class 1)

Class A (Derived Class)

Order of Constructor Call

1. C() (Class C's Constructor)
2. B() (Class B's Constructor)
3. A() (Class A's Constructor)

Order of Destructor Call

1. ~A() (Class A's Destructor)
2. ~B() (Class B's Destructor)
3. ~C() (Class C's Destructor)

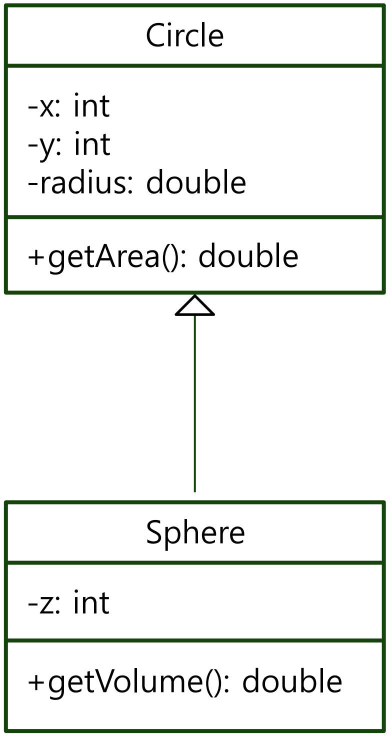
Constructor & Destructor with Inheritance: Example 1

```
class Parent {
 public:
  Parent() { cout << " Parent"; }
  ~Parent() { cout << " ~Parent"; }
};

class Child : public Parent {
 public:
  Child() { cout << " Child"; }
  ~Child() { cout << " ~Child"; }
};

class Test : public Child {
 public:
  Test() { cout << " Test"; }
  ~Test() { cout << " ~Test"; }
};
```

```
int main() {
  {
    Child child;
    cout << endl;
  }
  cout << endl;
  {
    Test test;
    cout << endl;
  }
  cout << endl;
  return 0;
}
```

```
Parent Child
~Child ~Parent
Parent Child Test
~Test ~Child ~Parent
```

Constructor & Destructor with Inheritance: Example 2



Circle

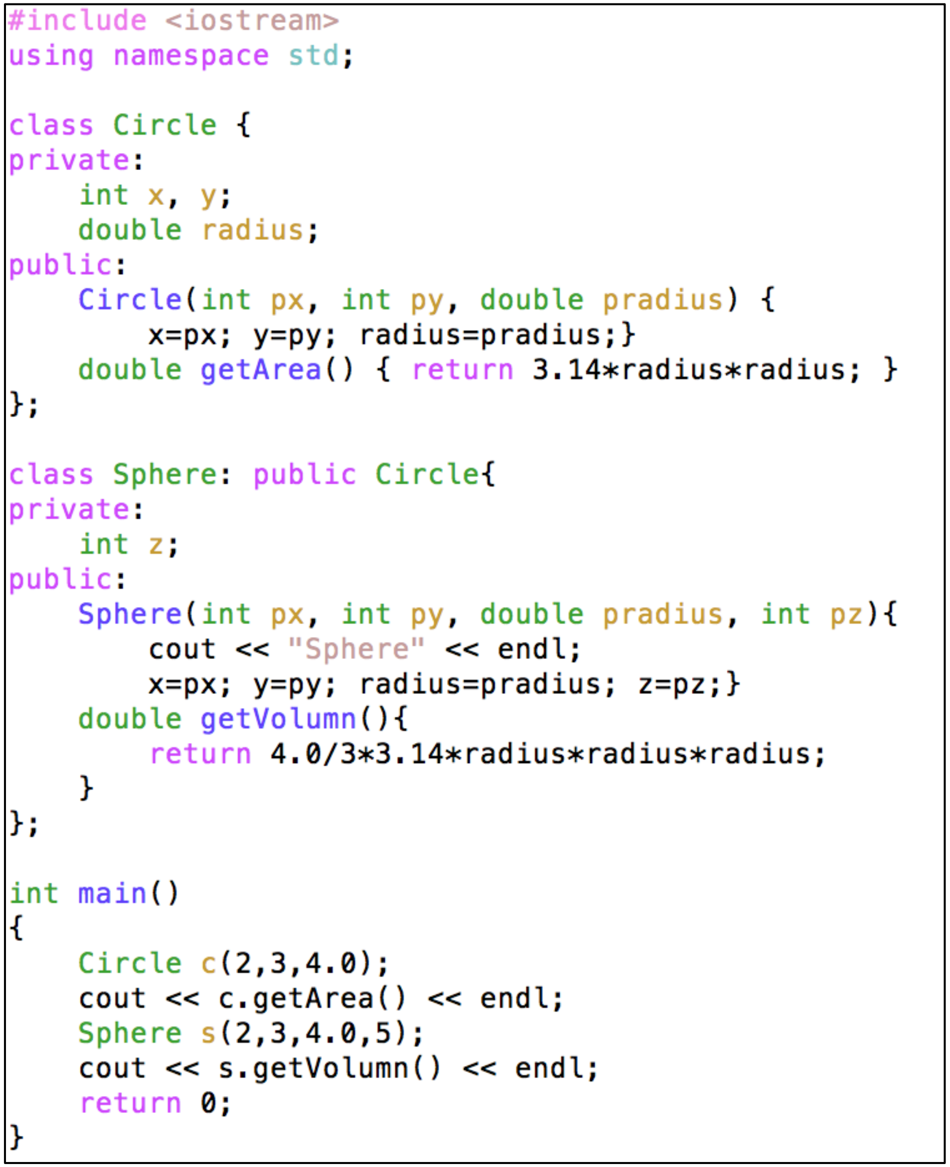
-x: int
-y: int
-radius: double

+getArea(): double

Sphere

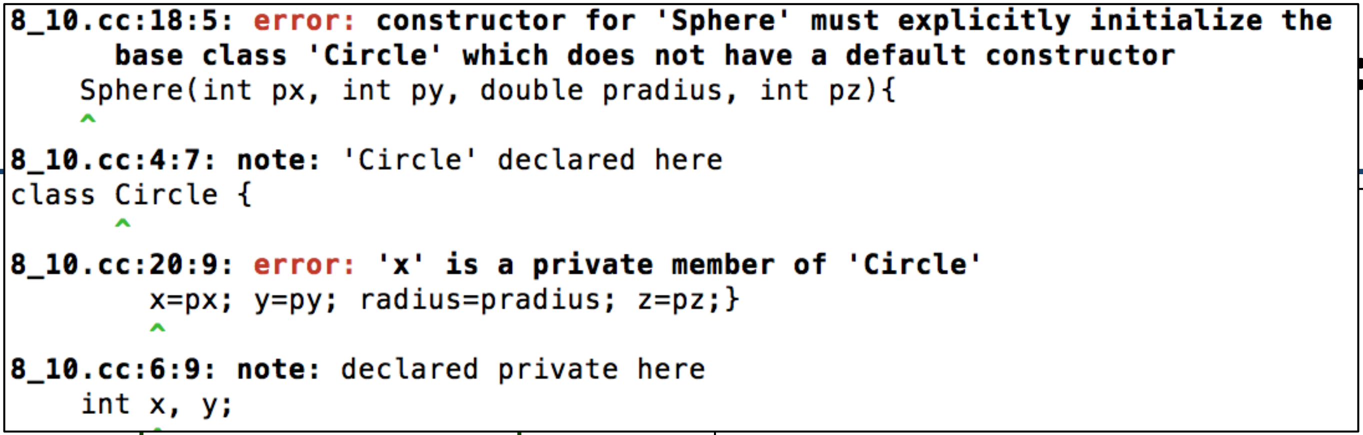
-z: int

+getVolume(): double

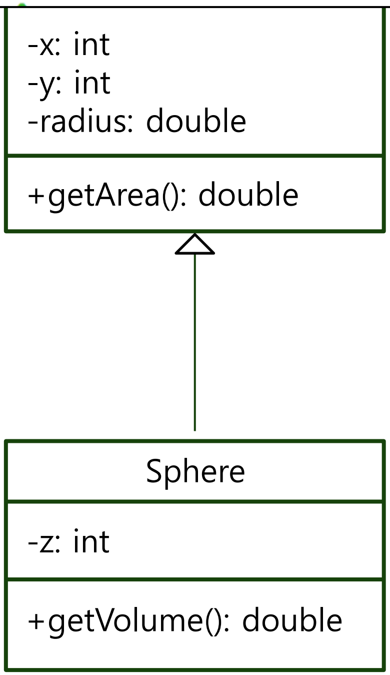


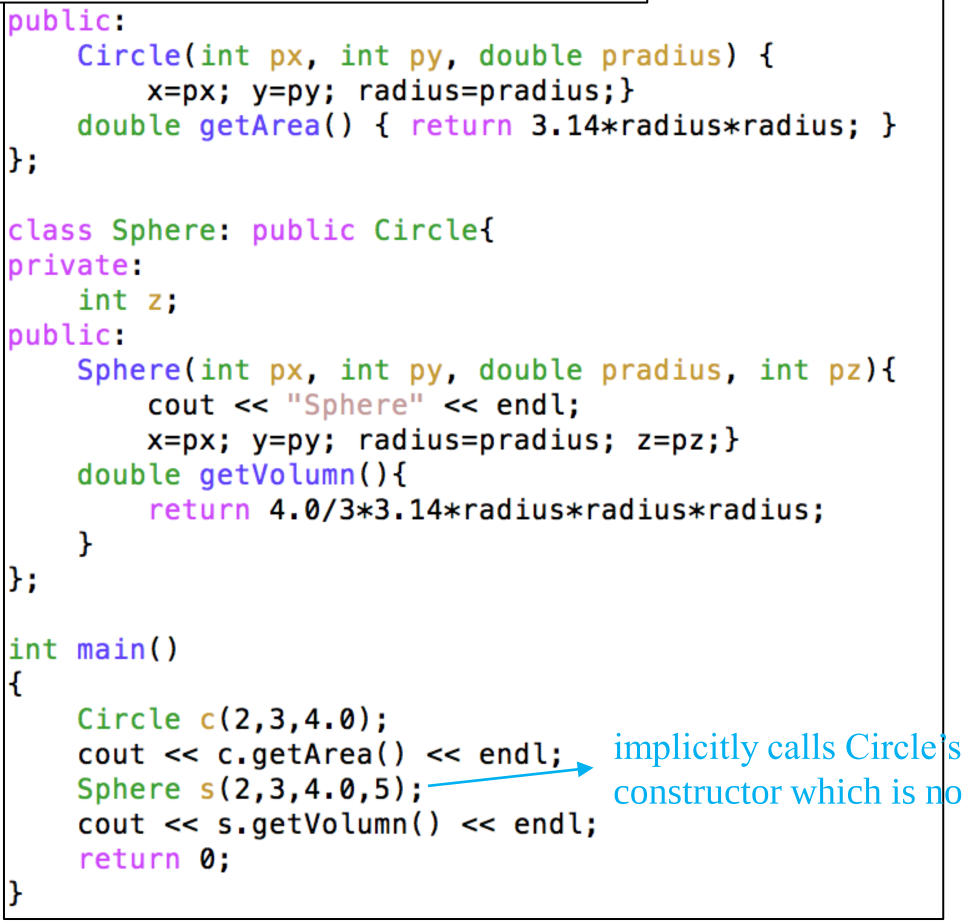
```
#include <iostream>
using namespace std;

class Circle {
private:
    int x, y;
    double radius;
public:
    Circle(int px, int py, double pradius) {
        x=px; y=py; radius=pradius;}
    double getArea() { return 3.14*radius*radius; }
};

class Sphere: public Circle{
private:
    int z;
public:
    Sphere(int px, int py, double pradius, int pz){
        cout << "Sphere" << endl;
        x=px; y=py; radius=pradius; z=pz;}
    double getVolumn(){
        return 4.0/3*3.14*radius*radius*radius;
    }
};

int main()
{
    Circle c(2,3,4.0);
    cout << c.getArea() << endl;
    Sphere s(2,3,4.0,5);
    cout << s.getVolumn() << endl;
    return 0;
}
```

: Example 2



```
8_10.cc:18:5: error: constructor for 'Sphere' must explicitly initialize the
      base class 'Circle' which does not have a default constructor
    Sphere(int px, int py, double pradius, int pz){
    ^
8_10.cc:4:7: note: 'Circle' declared here
class Circle {
      ^
8_10.cc:20:9: error: 'x' is a private member of 'Circle'
        x=px; y=py; radius=pradius; z=pz;}
        ^
8_10.cc:6:9: note: declared private here
    int x, y;
```

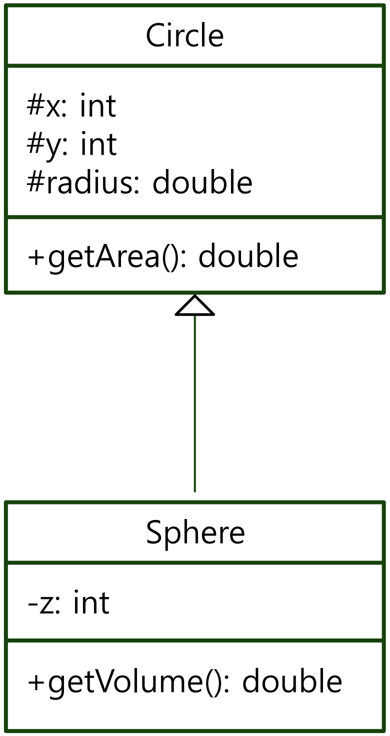




```
public:
    Circle(int px, int py, double pradius) {
        x=px; y=py; radius=pradius;}
    double getArea() { return 3.14*radius*radius; }
};

class Sphere: public Circle{
private:
    int z;
public:
    Sphere(int px, int py, double pradius, int pz){
        cout << "Sphere" << endl;
        x=px; y=py; radius=pradius; z=pz;}
    double getVolumn(){
        return 4.0/3*3.14*radius*radius*radius;
    }
};

int main()
{
    Circle c(2,3,4.0);
    cout << c.getArea() << endl;
    Sphere s(2,3,4.0,5);
    cout << s.getVolumn() << endl;
    return 0;
}
```

implicitly calls Circle's default constructor which is not defined

Constructor & Destructor with Inheritance: Example 2



Circle

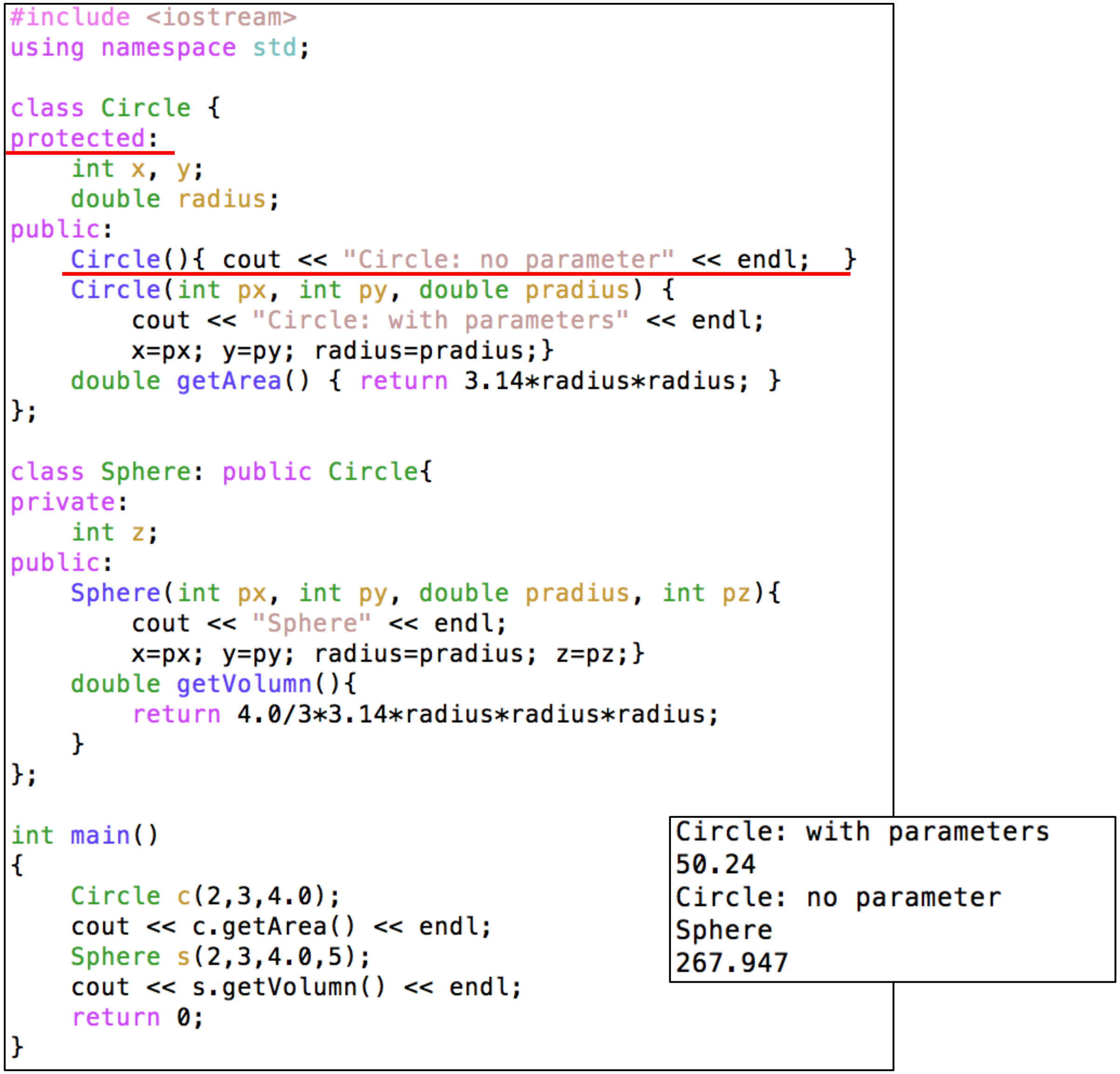
#x: int
#y: int
#radius: double

+getArea(): double

Sphere

-z: int

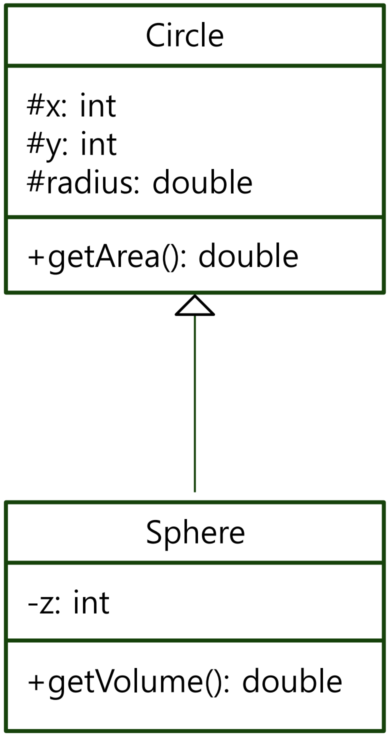
+getVolume(): double



```cpp
#include <iostream>
using namespace std;

class Circle {
protected:
    int x, y;
    double radius;
public:
    Circle(){ cout << "Circle: no parameter" << endl;  }
    Circle(int px, int py, double pradius) {
        cout << "Circle: with parameters" << endl;
        x=px; y=py; radius=pradius;}
    double getArea() { return 3.14*radius*radius; }
};

class Sphere: public Circle{
private:
    int z;
public:
    Sphere(int px, int py, double pradius, int pz){
        cout << "Sphere" << endl;
        x=px; y=py; radius=pradius; z=pz;}
    double getVolumn(){
        return 4.0/3*3.14*radius*radius*radius;
    }
};

int main()
{
    Circle c(2,3,4.0);
    cout << c.getArea() << endl;
    Sphere s(2,3,4.0,5);
    cout << s.getVolumn() << endl;
    return 0;
}
```

```
Circle: with parameters
50.24
Circle: no parameter
Sphere
267.947
```

Constructor & Destru



Circle

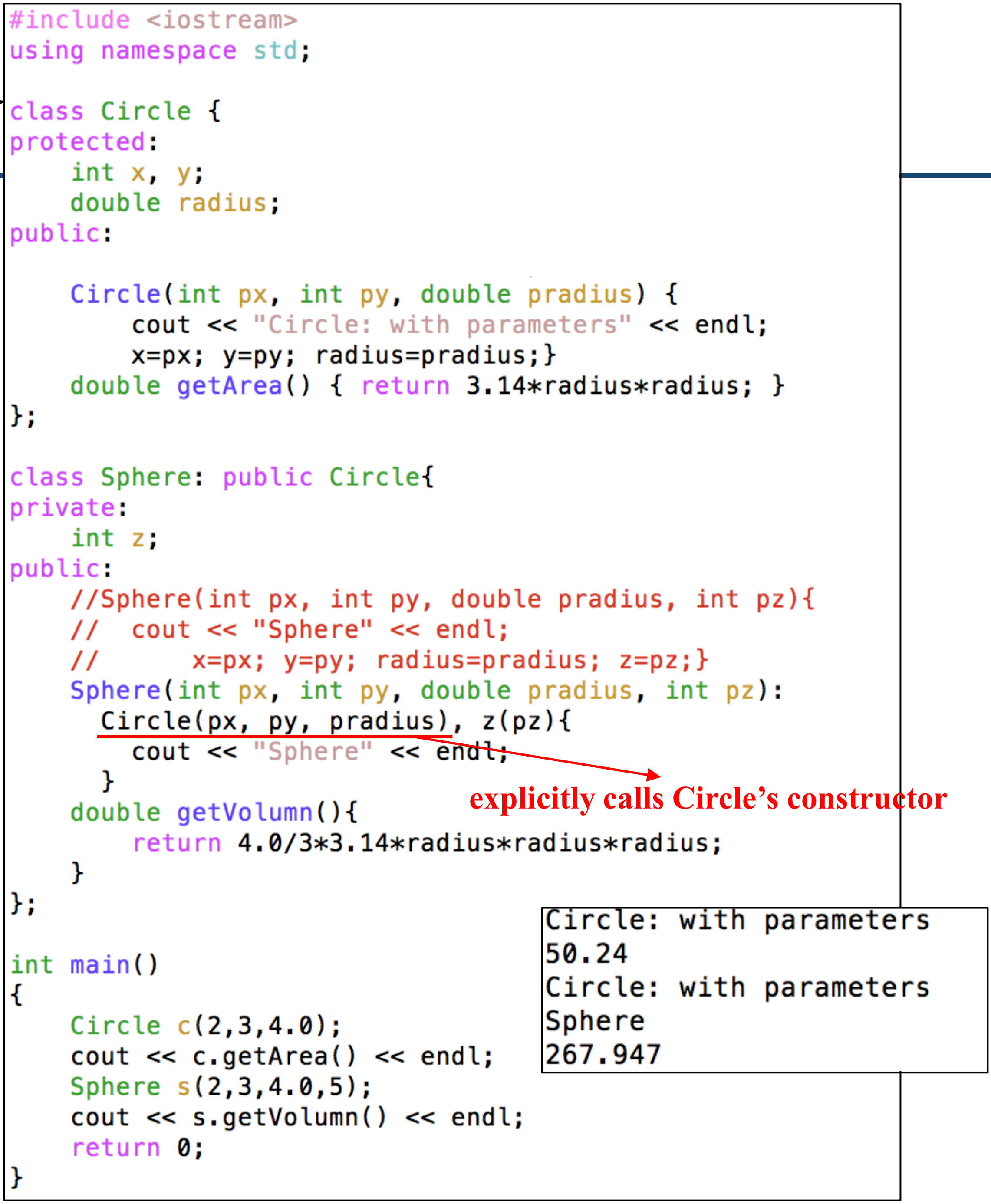
#x: int
#y: int
#radius: double

+getArea(): double

Sphere

-z: int

+getVolume(): double

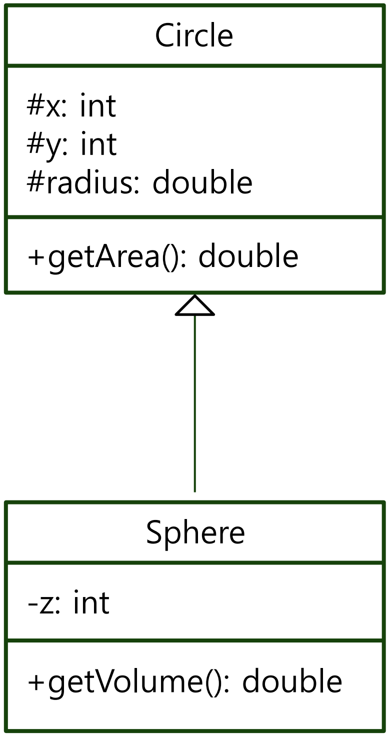


```
#include <iostream>
using namespace std;

class Circle {
protected:
    int x, y;
    double radius;
public:

    Circle(int px, int py, double pradius) {
        cout << "Circle: with parameters" << endl;
        x=px; y=py; radius=pradius;}
    double getArea() { return 3.14*radius*radius; }
};

class Sphere: public Circle{
private:
    int z;
public:
    //Sphere(int px, int py, double pradius, int pz){
    //  cout << "Sphere" << endl;
    //      x=px; y=py; radius=pradius; z=pz;}
    Sphere(int px, int py, double pradius, int pz):
      Circle(px, py, pradius), z(pz){
        cout << "Sphere" << endl;
      }
    double getVolumn(){
        return 4.0/3*3.14*radius*radius*radius;
    }
};

int main()
{
    Circle c(2,3,4.0);
    cout << c.getArea() << endl;
    Sphere s(2,3,4.0,5);
    cout << s.getVolumn() << endl;
    return 0;
}
```

explicitly calls Circle’s constructor

```
Circle: with parameters
50.24
Circle: with parameters
Sphere
267.947
```

Constructor & Dest



Circle

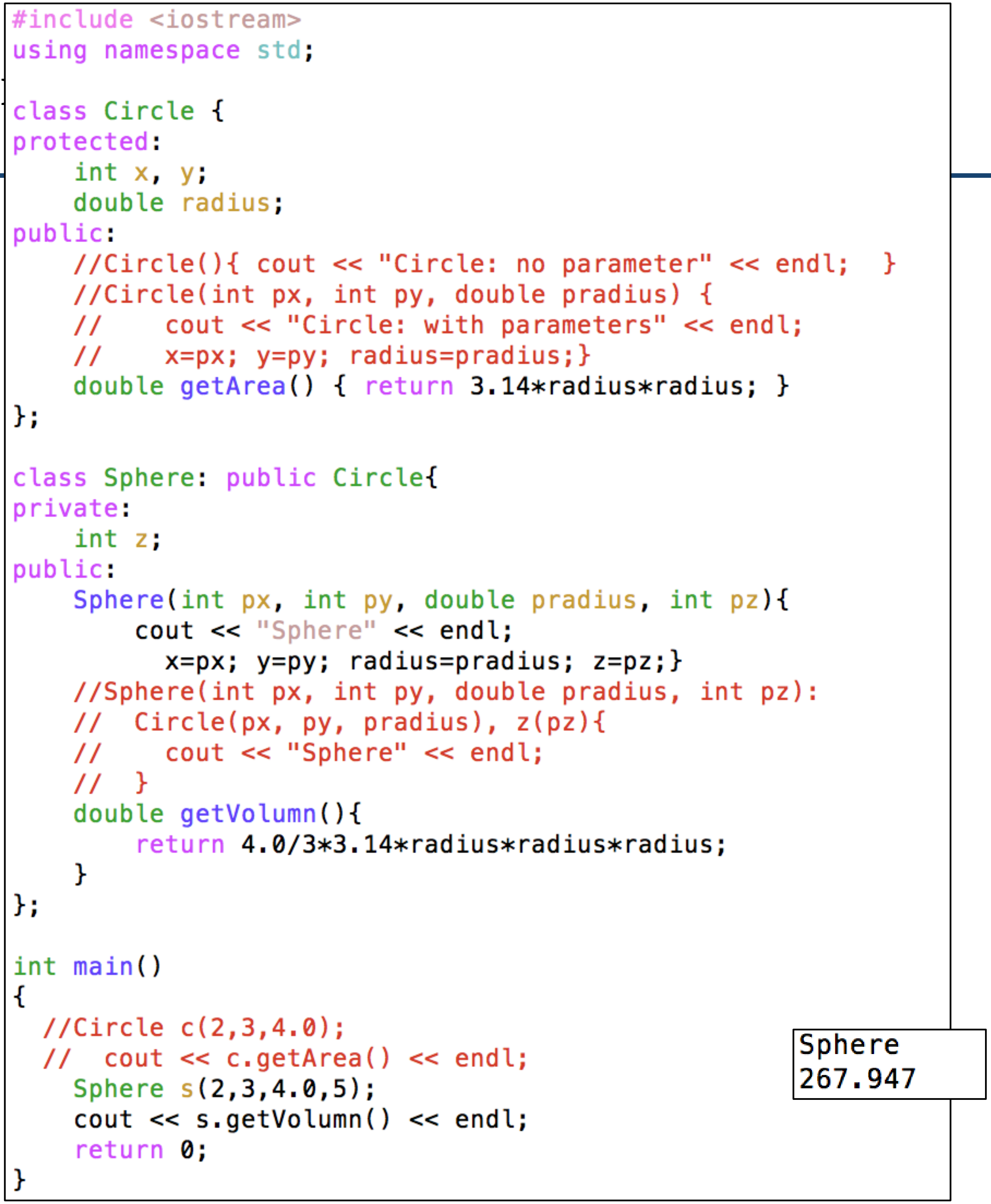
#x: int
#y: int
#radius: double

+getArea(): double

Sphere

-z: int

+getVolume(): double



```
#include <iostream>
using namespace std;

class Circle {
protected:
    int x, y;
    double radius;
public:
    //Circle(){ cout << "Circle: no parameter" << endl;  }
    //Circle(int px, int py, double pradius) {
    //    cout << "Circle: with parameters" << endl;
    //    x=px; y=py; radius=pradius;}
    double getArea() { return 3.14*radius*radius; }
};

class Sphere: public Circle{
private:
    int z;
public:
    Sphere(int px, int py, double pradius, int pz){
        cout << "Sphere" << endl;
          x=px; y=py; radius=pradius; z=pz;}
    //Sphere(int px, int py, double pradius, int pz):
    //  Circle(px, py, pradius), z(pz){
    //    cout << "Sphere" << endl;
    //  }
    double getVolumn(){
        return 4.0/3*3.14*radius*radius*radius;
    }
};

int main()
{
  //Circle c(2,3,4.0);
  //  cout << c.getArea() << endl;
    Sphere s(2,3,4.0,5);
    cout << s.getVolumn() << endl;
    return 0;
}
```

```
Sphere
267.947
```

Quiz 2

- Go to https://www.slido.com/
- Join #**csd-ys**
- Click "Polls"

- Submit your answer in the following format:
  - **Student ID: Your answer**
  - **e.g. 2017123456: 4)**

- Note that your quiz answer must be submitted **in the above format** to receive a quiz score!

Member initializer list with Inheritance

- You can't initialize (by a member initializer list) a parent class member in the child class.
- The child class can indirectly initialize the parent's members by calling the parent's constructor in its member initializer list.

```
class A
{
public:
    int memberA;
    A(int n):memberA(n) { }
};

class B: public A
{
public:
    B():memberA(10) {}  // error
};
```

```
class A
{
public:
    int memberA;
    A(int n):memberA(n) { }
};

class B: public A
{
public:
    B():A(10) {}  // Ok
};
```

Person Example - outline

```
// Person class.

class Person {
 public:
  Person(const string& name);

  const string& name();
  const string& address();
  void ChangeAddress(const string& addr);
};

// Student class.

class Student : public Person {
 public:
  Student(const string& name);

  void RegisterClass(int class_id);
  int GetNumClasses();
  int ComputeTuition();
};
```

```
// Employee class

class Employee : public Person {
 public:
  Employee(const string& name,int salary);

  int salary();
  int ComputeIncomeTax();
  void SetSalary(int salary);
};

// Faculty class

class Faculty : public Employee {
 public:
  Faculty(const string& name, int salary);

  void TeachClass(int class_id);
};
```

Person Example - implementation

person.h

```
#ifndef _PERSON_H_
#define _PERSON_H_

#include <string>

class Person {
 public:
  Person(const std::string& name)
      : name_(name) {}

  const std::string& name() {
    return name_;
  }
  const std::string& address() {
    return address_;
  }

  void ChangeAddress(const std::string& addr) {
    address_ = addr;
  }

 private:
  std::string name_, address_;
};

#endif
```

student.h

```
#ifndef _STUDENT_H_
#define _STUDENT_H_

#include <set>
#include "person.h"

class Student : public Person {
 public:
  Student(const std::string& name)
      : Person(name) {}

  void RegisterClass(int class_id) {
    registered_classes_.insert(class_id);
  }

  int GetNumClasses() {
    return registered_classes_.size();
  }

  int ComputeTuition() {
    return registered_classes_.size() * 100
        + 500;
  }

 private:
  std::set<int> registered_classes_;
};

#endif
```

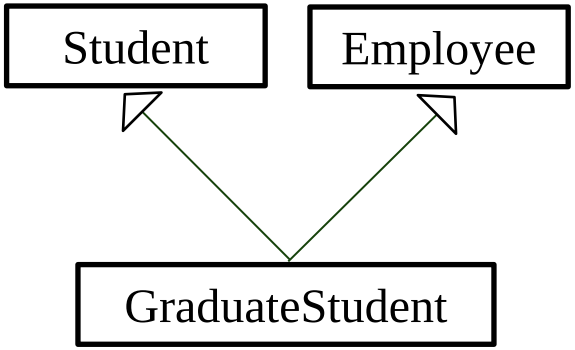
Person Example - implementation

main.cc

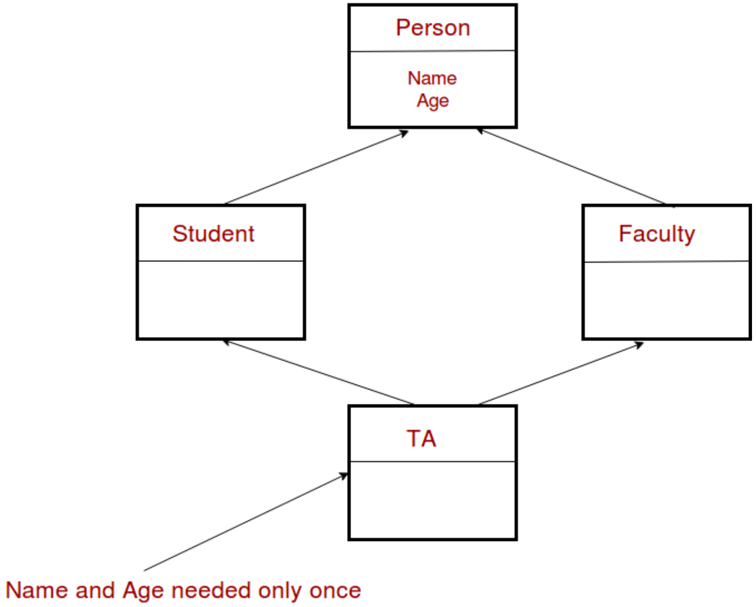
```
#include "employee.h"
#include "faculty.h"
#include "student.h"
using namespace std;

int main() {
  Student john("John"), david("David");
  Employee susan("Susan", 200);
  Faculty daniel("Daniel", 100);

  john.ChangeAddress("New York");
  david.RegisterClass(101);
  daniel.TeachClass(101);
  daniel.TeachClass(102);

  return 0;
}
```

Multiple Inheritance

- Inheriting from two or more base classes.
  - The derived class has all the members of base classes



- Issues
  - Ambiguity
    - What happens if base classes has same-named members?
  - The diamond problem
    - What happens if parent classes are derived from the same grandparent class?



Multiple Inheritance: Example

```
class Person {
 public:
 // ...
};
class Student : public Person {
 public:
 // ...
};
class Employee : public Person {
 public:
 // ...
};

// Multiple inheritance example.
class GraduateStudent
    : public Student, public Employee
{
 public:
  GraduateStudent(const string& name,
                  int salary)
      : Student(name),
        Employee(name + "*", salary) {
}
};
```

```
int main() {
  GraduateStudent mark("Mark", 50);

  cout << mark.GetNumClasses() << endl;
  cout << mark.salary() << endl;
  return 0;
}
```

Multiple Inheritance: Example

```cpp
class Person {
 public:
 // ...
};
class Student : public Person {
 public:
 // ...
  void DoSomething();
};
class Employee : public Person {
 public:
 // ...
  void DoSomething();
};
// Multiple inheritance example.
class GraduateStudent
    : public Student, public Employee {
public:
  GraduateStudent(const string& name,
                  int salary)
      : Student(name),
        Employee(name + "*", salary) {}
};
```

```cpp
int main() {
  GraduateStudent mark("Mark", 50);

  // Eror - ambiguous function DoSomething
  mark.DoSomething();

  return 0;
}
```

Multiple Inheritance

- Actually, you can avoid these problem by using `virtual` inheritance in C++.

- General advice: Avoid using multiple inheritance as much as possible.
  - It is commonly believed that multiple inheritance tends to mass things up.
  - That's why Java forbids multiple inheritance.

- Note that multiple inheritance from *interfaces* (pure abstract classes in C++) can be very helpful.
  - Java only allows multiple inheritance from *interfaces* ("implements" multiple interfaces in Java)

Const: review

- Const variables

```
const int MAX = 100;
```

- Const parameters

```
int sum(const int x, const int y) { . . . }
```

- Pointer to const and const pointer

```
const int *pnum1 = &num1;
int* const pnum2 = &num2;
```

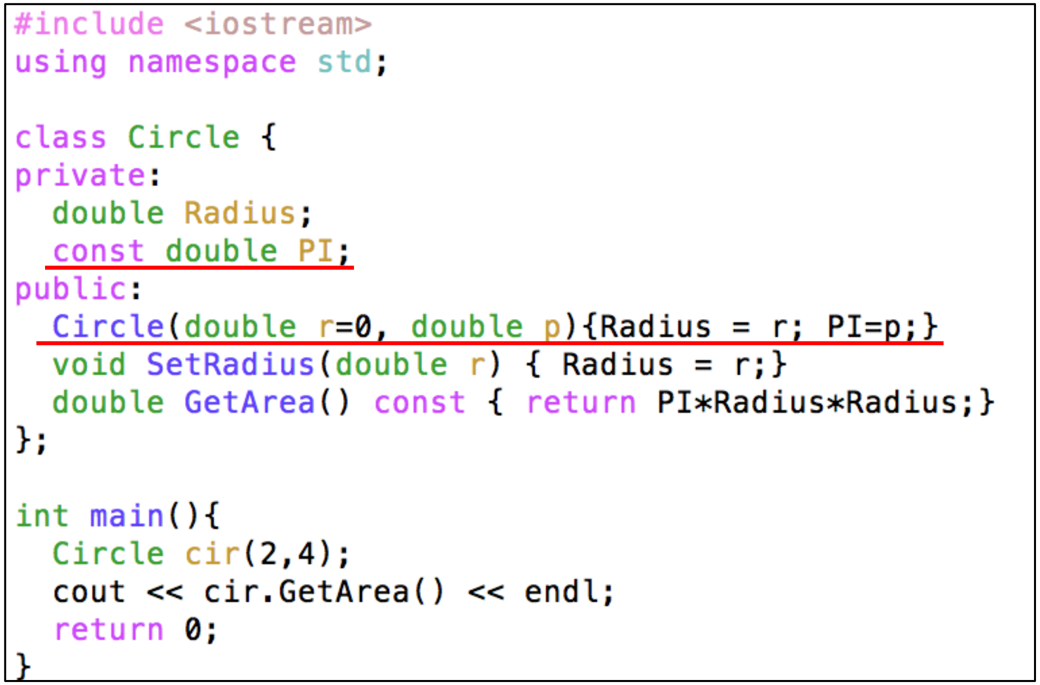
Const & Class

- Const member variables
  - **should be initialized in *member initializer list* of a constructor**

- Const member functions
  - can read the value of member variables
  - **cannot change the value of member variables**

- Const object
  - cannot change the value of member variables on a const object
  - **cannot call non-const member functions on a const object**

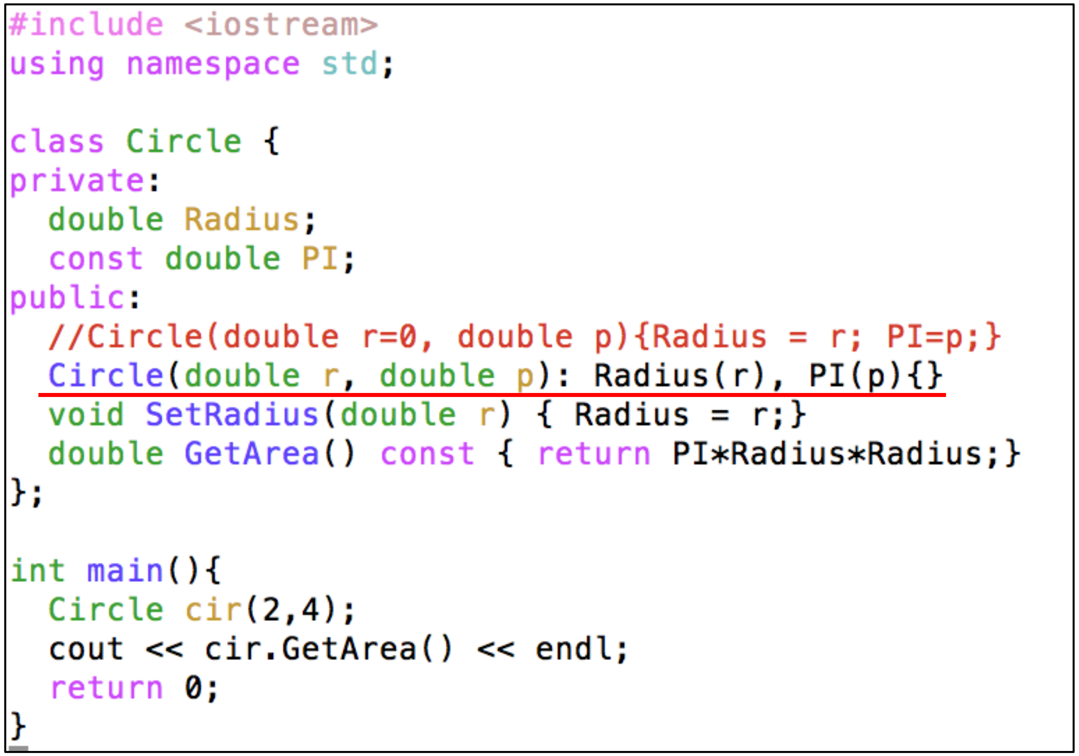
Const: member variables



```
#include <iostream>
using namespace std;

class Circle {
private:
  double Radius;
  const double PI;
public:
  Circle(double r=0, double p){Radius = r; PI=p;}
  void SetRadius(double r) { Radius = r;}
  double GetArea() const { return PI*Radius*Radius;}
};

int main(){
  Circle cir(2,4);
  cout << cir.GetArea() << endl;
  return 0;
}
```

???

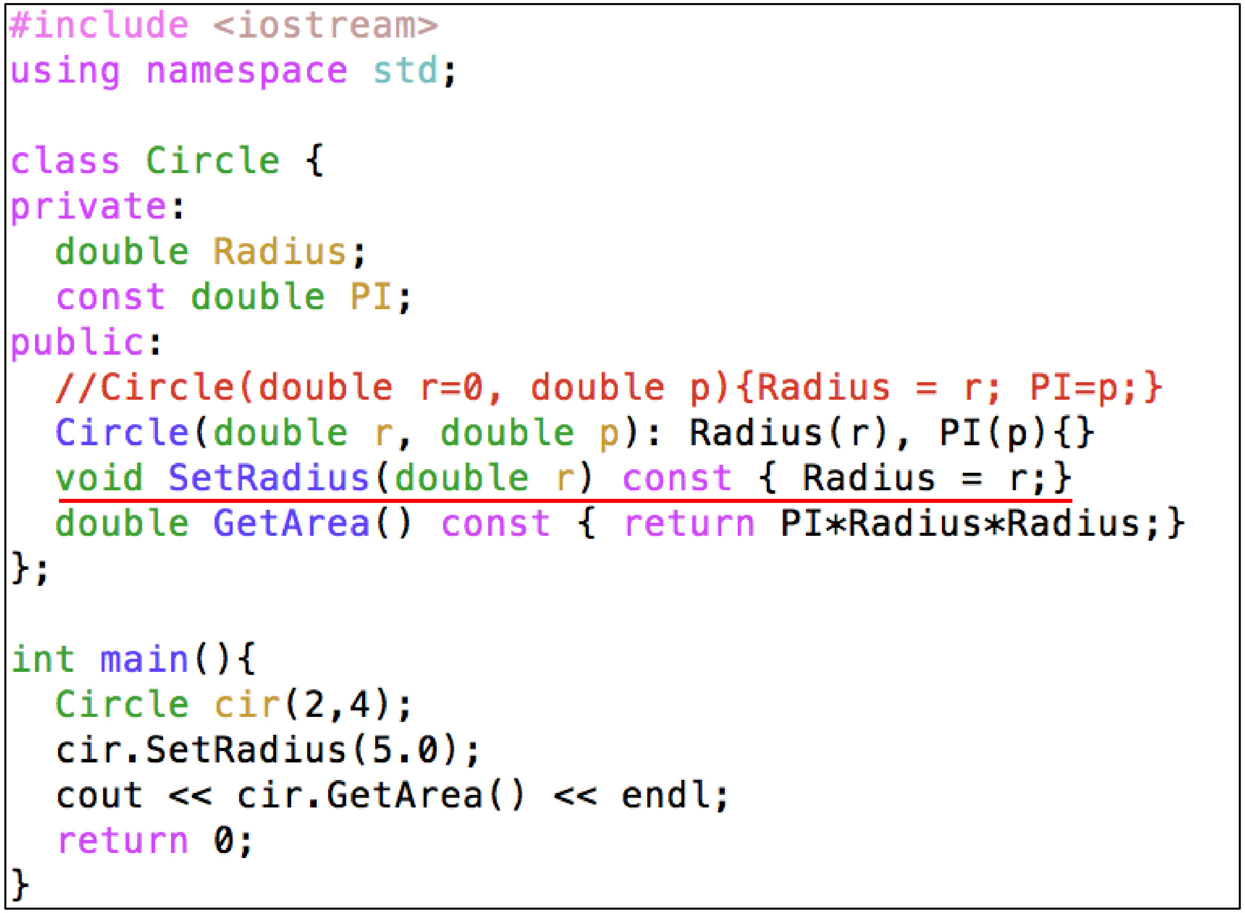
Const: member variables



```
#include <iostream>
using namespace std;

class Circle {
private:
  double Radius;
  const double PI;
public:
  //Circle(double r=0, double p){Radius = r; PI=p;}
  Circle(double r, double p): Radius(r), PI(p){}
  void SetRadius(double r) { Radius = r;}
  double GetArea() const { return PI*Radius*Radius;}
};

int main(){
  Circle cir(2,4);
  cout << cir.GetArea() << endl;
  return 0;
}
```

- Const member variables
  - – **should be initialized in *member initializer list* of a constructor**

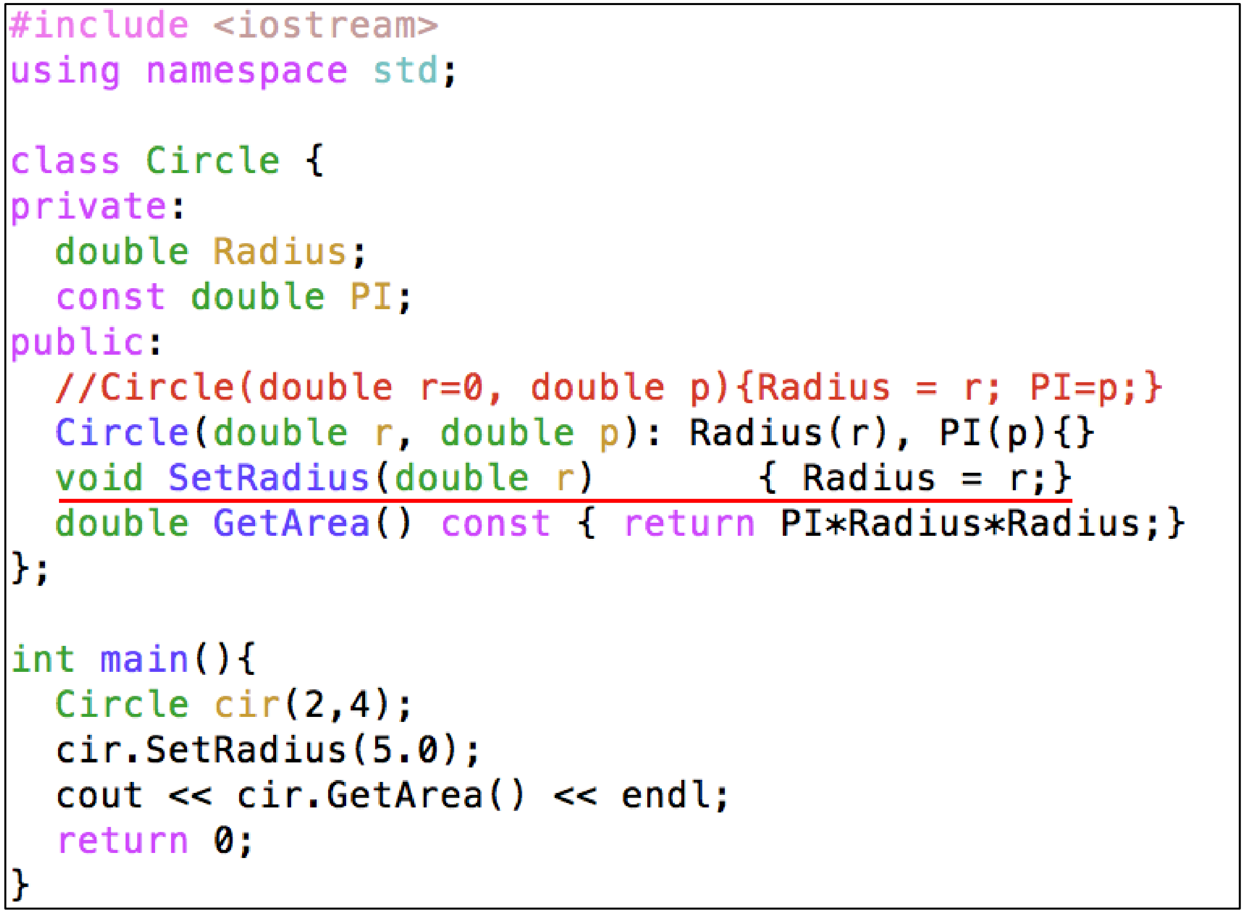
Const: member function



```
#include <iostream>
using namespace std;

class Circle {
private:
  double Radius;
  const double PI;
public:
  //Circle(double r=0, double p){Radius = r; PI=p;}
  Circle(double r, double p): Radius(r), PI(p){}
  void SetRadius(double r) const { Radius = r;}
  double GetArea() const { return PI*Radius*Radius;}
};

int main(){
  Circle cir(2,4);
  cir.SetRadius(5.0);
  cout << cir.GetArea() << endl;
  return 0;
}
```

???

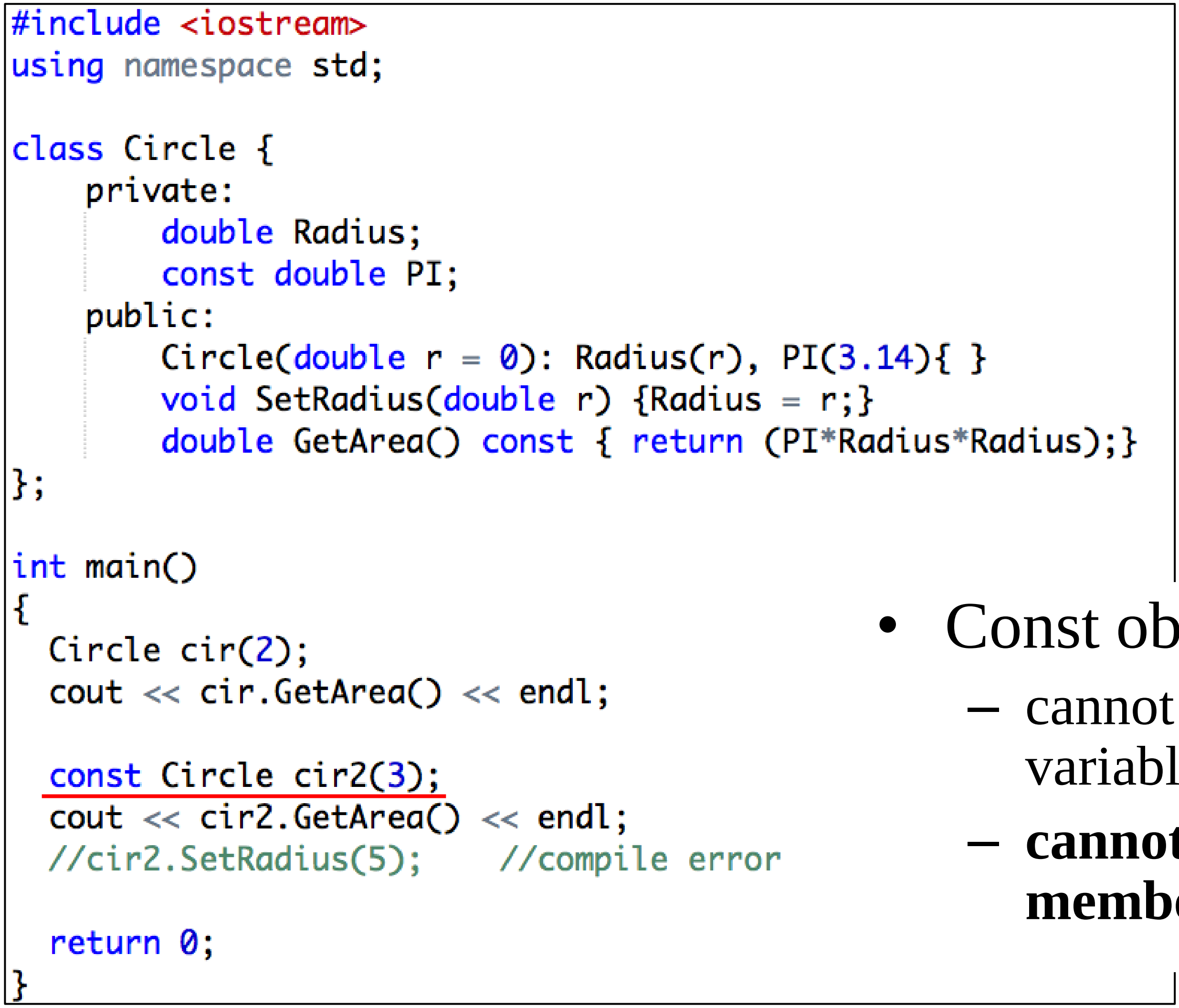
Const: member function



```
#include <iostream>
using namespace std;

class Circle {
private:
  double Radius;
  const double PI;
public:
  //Circle(double r=0, double p){Radius = r; PI=p;}
  Circle(double r, double p): Radius(r), PI(p){}
  void SetRadius(double r)       { Radius = r;}
  double GetArea() const { return PI*Radius*Radius;}
};

int main(){
  Circle cir(2,4);
  cir.SetRadius(5.0);
  cout << cir.GetArea() << endl;
  return 0;
}
```

- Const member functions
  - can read member variables, **cannot update member variables**

Const: object



```
#include <iostream>
using namespace std;

class Circle {
    private:
        double Radius;
        const double PI;
    public:
        Circle(double r = 0): Radius(r), PI(3.14){ }
        void SetRadius(double r) {Radius = r;}
        double GetArea() const { return (PI*Radius*Radius);}
};

int main()
{
  Circle cir(2);
  cout << cir.GetArea() << endl;

  const Circle cir2(3);
  cout << cir2.GetArea() << endl;
  //cir2.SetRadius(5);    //compile error

  return 0;
}
```

- Const object
  - cannot update member variables
  - **cannot call non-const member functions**

Quiz 3

- Go to https://www.slido.com/
- Join #**csd-ys**
- Click "Polls"

- Submit your answer in the following format:
  - **Student ID: Your answer**
  - **e.g. 2017123456: 4)**

- Note that your quiz answer must be submitted **in the above format** to receive a quiz score!

Class Inheritance Types

- Types of inheritance: `public`, `protected`, and `private`.
  - Depending on the inheritance types, the parent's member has diffe rent access control IN the child class.
  - Most commonly used is **public inheritance** (and probably it's the only useful inheritance).

Type of inheritance	Parent's public member	Parent's protected member	Parent's private member
public	public	protected	x (not accessible)
protected	protected	protected	x (not accessible)
private	private	private	x (not accessible)

Example of Private Inheritance

```
class A {
 public:
  void APublic() {}
 protected:
  void AProtected() {}
 private:
  void APrivate() {}
};

// Private inheritance.
class CA : private A {
 public:
  void CAPublic() {
    APublic();     // OK.
    AProtected();  // OK.
    APrivate();    // Error.
  }
  void CAPublic2() {}
 protected:
  void CAProtected() {
  }
 private:
  void CAPrivate() {
  }
};
```

```
class Client : public CA {
  void Function() {
    APublic();      // Error.
    AProtected();   // Error.
    APrivate();     // Error.

    CAPublic();     // Error.
    CAPublic2();    // OK.
    CAProtected();  // OK.
    CAPrivate();    // Error.
  }
};
```

```
// Main routine.

int main() {
  CA ca;
  ca.APublic();   // Error.
  ca.CAPublic();  // Error
  ca.CAPublic2(); // OK.
  ...
}
```

Next Time

- Labs for this lecture:
  - Lab1: Assignment 8-1
  - Lab2: Assignment 8-2
- Next lecture:
  - 9 - Polymorphism 1