# CSCI 262
# Data Structures

21 – Inheritance

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## Inheritance Overview

- Classes can *inherit* from other classes
  - Properties (variables)
  - Behavior (methods)
- Inheritance serves various functions
  - Modeling of class relationships
  - Code reuse
  - Subtyping/polymorphism

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## Inheritance Example

Superclass aka "base" or "parent" class.

Subclass aka "derived" or "child" class.

This signifies that dog inherits from animal. (The "public" just means all members have the same visibility in the subclass as in the superclass.)

```
class animal {
public:
      string name;
      void print();
};

class dog : public animal {
public:
      string breed;
};
```

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## Inheritance: Modeling Relationships

```
class cat : public animal {
};
```

We say cat "is a" type of animal*

*This language can lead to bad modeling choices. E.g., a square "is a" type of rectangle. If we model this way in C++, a natural choice is to give rectangle properties of height and width. If square inherits from rectangle, it gets these two independent properties, but in a square, they must be identical. So not every "is a" relationship in real life makes sense in C++!

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## Inheritance: Properties

Note that animal defined a property:

```
string name;
```

This is inherited by dog and cat.

We can use name in dog and cat because it was defined by the superclass:

```
dog d;
cat c;
d.name = "Rex";
c.name = "Fluffy";
```

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## Inheritance: Properties

Note that dog defines a new property,

```
string breed;
```

This is unique to dog; we can't use it in animal or cat:

```
dog d;
cat c;
d.breed = "Dachshund";
c.breed = "Tabby";
```

error!

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## Inheritance: Behavior

Behaviors can also be inherited, leading to very powerful code reuse.

E.g.,

```
void animal::print() {
      cout << "My name is " << name << ". ";
      cout << endl;
}
```

defines a reasonable print behavior for cat and dog.

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## Inheritance: Overrides

If we don't like the superclass behavior, we can change it in the subclass:

```
class dog : public animal {
public:
    string breed;
    void print();
};
void dog::print() {
    cout << "My name is " << name << "." << endl;
    cout << "I am a " << breed << "." << endl;
}
```

**You cannot**:

- Override properties
- Change the return type of methods

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## Inheritance: Calling on the Super

We can improve our print() method slightly by reusing the superclass behavior:

```
dog::print() {
      animal::print();
      cout << "I am a " << breed << "." << endl;
}
```

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## Example So Far

```
…
dog d;
cat c;
d.name = "Rex";
d.breed = "Dachshund";
c.name = "Fluffy";
c.print();
d.print();
…
```

I encourage you to try these code snippets for yourself, and modify them to see what else you can do.

Output is:

```
My name is Fluffy.
My name is Rex.
I am a Dachshund.
```

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## Inheritance: Polymorphism

Note we can now use dogs and cats wherever we would use an animal:

```
…
void print_animal(animal &a) { a.print(); }
print_animal(c);
print_animal(d);
…
```

What does this output?

(Hint: it is different from previous page!)

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## Inheritance: Polymorphism

What happens here:

```
…
void print_animal(animal &a) { a.print(); }
print_animal(c);
print_animal(d);
…
```

is that, even though the parameter a holds a reference to the dog object, C++ doesn't treat it like a dog in terms of its `print()` behavior.

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## Inheritance: Polymorphism

Let's fix this:

```
class animal {
public:
    string name;
    virtual void print();
};

print_animal(c);
print_animal(d);
```

Output is:

```
My name is Fluffy.
My name is Rex.
I am a Dachshund.
```

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## Inheritance: Polymorphism

Now using pointers, same output:

```
animal* A[2];
A[0] = &c;
A[1] = &d;
for (int j = 0; j < 2; j++) A[j]->print();
```

Output is:

```
My name is Fluffy.
My name is Rex.
I am a Dachshund.
```

Note, how this is different:

```
animal a = d;  // default copy constructor called – now just an animal!
a.print();
```

Output is:

```
My name is Rex.
```

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## Polymorphism

- The word **polymorphism** means having many forms. Typically, polymorphism occurs when there is a hierarchy of classes and they are related by inheritance.
- C++ polymorphism means that a call to a member function will cause a different function to be executed depending on the type of object that invokes the function.

Polymorphism in C++ - tutorialspoint.com. (n.d.). Retrieved October 25, 2016, from https://www.tutorialspoint.com/cplusplus/cpp_polymorphism.htm

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## Inheritance: Abstract Classes

An abstract class is one which:

- Contains at least one "pure virtual" method
- Cannot be instantiated
- Can only be used via inheritance

```
class animal {
public:
    string name;
    void print();
    virtual void speak() = 0;
};
```

Notation to designate as a pure virtual method.

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## Abstract Classes

Pure virtual methods *are not defined in the abstract class.*

(Non-abstract) children of abstract classes **must** implement (override) any pure virtual methods.

However, we can *use* pure virtual methods in the abstract class:

```
void animal::print() {
    cout << "My name is " << name << ". ";
    speak();
    cout << endl;
}
```

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## Inheritance: Constructors

- Normally, a subclass calls the default constructor (i.e. no parameters) of the superclass before executing its own constructor.
- You can force the subclass to call a different constructor using this form in the definition:

```
animal::animal(string nm) { name = nm; }

dog::dog(string n, string b) : animal(n) {
      breed = b ;
}
```

Superclass constructor call

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## Final Example

```
class animal {
public:
        string name;
        virtual void print();
        virtual void speak() = 0;
};

class dog : public animal {
public:
        string breed;
        void print();
        void speak() { cout << "Woof!"; }
};

class cat : public animal {
public:
        void speak() { cout << "Meow."; }
};
```

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## Final Example II

```
void animal::print() {
       cout << "My name is " << name << ". ";
       speak();
       cout << endl;
}

void dog::print() {
       animal::print();
       cout << "I am a " << breed << "." << endl;
}

void print_animal(animal& a) { a.print(); }
```

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## Final Example III

```
int main() {
       dog d;
       cat c;
       d.name = "Rex";
       d.breed = "Dachshund";
       c.name = "Fluffy";

       print_animal(c);
       print_animal(d);

       return 0;
}
```

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## Final Example Output

```
My name is Fluffy. Meow.
My name is Rex. Woof!
I am a Dachshund.
```

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## Up Next

- Friday, April 26
  - Lab 12 – Inheritance
  - Extra credit APT due
- Monday, April 29
  - TBA
- Wednesday, May 1
  - Final exam review
  - Project 5 due

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