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CSE 374

# Programming Concepts & Tools

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Lecture 20 – C++ Subclasses and Inheritance

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# Subclassing

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- In many ways, OOP is “all about” subclasses overriding methods
  - Often not what you want, but what makes OOP fundamentally different from, say, functional programming (Scheme, ML, Haskell, etc., cf. CSE413)
- C++ gives you lots more options than Java with different defaults, so it’s easy to scream “compiler bug” when you mean “I’m using the wrong feature”...

# Subclassing in C++

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- Basic subclassing:

```
class D : public C { ... }
```

- This is *public inheritance*; C++ has other kinds too (won't cover)
  - Differences affect visibility and issues when you have multiple superclasses (won't cover)
  - So **do not forget** the `public` keyword

# More on subclassing

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- Not all classes have superclasses (unlike Java with Object)
  - (and classes can have multiple superclasses — more general and complexity-prone than Java)
- Terminology
  - Java (and others): “superclass” and “subclass”
  - C++ (and others): “base class” and “derived class”
- Our example code: **House** derives from **Land** which derives from **Property** (read the code, no time for detailed presentation)
- As in Java, can add fields/methods/constructors, and override methods

# Constructor and destructors

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- Constructor of base class gets called before constructor of derived class
  - Default (zero-arg) constructor unless you specify a different one after the `:` in the constructor
  - Initializer syntax:  
`Foo::Foo(...) : Bar(args); it(x) { ... }`
    - Needed to execute superclass constructor with arguments; also works on instance variables and is preferred in production code (slogan: “initialization preferred over assignment”)
- Destructor of base class gets called after destructor of derived class
- So constructors/destructors really extend rather than override, since that is typically what you want
  - Java is the same

# Method overriding, part 1

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- If a derived class defines a method with the same method name and argument types as one defined in the base class (perhaps because of an ancestor), it *overrides* (i.e., replaces) rather than *extends*
- If you want to use the base-class code, you specify the base class when making a method call (`class::method(...)`)
  - Like `super` in Java (no such keyword in C++ since there may be multiple inheritance)
- Warning: the title of this slide is *part 1*

# Casting and subtyping

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- An object of a derived class *cannot* be cast to an object of a base class.
  - For the same reason a `struct T1 {int x,y,z;}` cannot be cast to type `struct T2 {int x, y;}` (different size)
- A pointer to an object of a derived class *can* be cast to a pointer to an object of a base class.
  - For the same reason a `struct T1*` can be cast to type `struct T2*` (pointers to a location in memory)
  - (Story not so simple with multiple inheritance)
- After such an *upcast*, field-access works fine (prefix), but what do method calls mean in the presence of overriding?

# An important example

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```
class A {
public:
    void m1 () { cout << "a1"; }
    virtual void m2 () { cout << "a2"; }
};
class B : public A {
    void m1 () { cout << "b1"; }
    void m2 () { cout << "b2"; }
};
void f () {
    A* x = new B ();
    x->m1 ();
    x->m2 ();
}
```

## In words...

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- A **non-virtual method-call** is *resolved* using the (compile-time) type of the *receiver* expression
- A **virtual method-call** is *resolved* using the (run-time) class of the *receiver object* (what the expression evaluates to)
  - Like in Java
  - Called “dynamic dispatch”
- A method-call is virtual if the method called is marked **virtual** or overrides a virtual method
  - So “one virtual” somewhere up the base-class chain is enough, but it’s probably better style to repeat it

# More on two method-call rules

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- For software-engineering, virtual and non-virtual each have advantages:
  - Non-virtual – can look at the code to know what you’re calling (even if subclass defines the same function)
  - Virtual – easier to extend code already written
- The implementations are the same and different:
  - Same: Methods just become functions with one extra argument *this* (pointer to receiver)
  - Different:
    - Non-virtual: linker can plug in code pointer
    - Virtual: At run-time, look up code pointer via “secret field” in the object

# Destructors revisited

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```
class B : public A { ... }  
...  
B * b = new B();  
A * a = b;  
delete a;
```

- Will `B::~~B()` get called (before `A::~~A()`)?
- Only if `A::~~A()` was declared `virtual`
  - Rule of thumb: Declare destructors virtual; usually what you want

# Downcasts

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Old news:

- C pointer-casts: unchecked; better know what you are doing
- Java: checked; may raise **ClassCastException** (checks “secret field”)

New news:

- C++ has “all the above” (several different kinds of casts)
- If you use single-inheritance and know what you are doing, the C-style casts (same pointer, assume more about what is pointed to) should work fine for downcasts
- Worth learning about the differences on your own

# Pure virtual methods

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A C++ “pure virtual” method is like a Java “abstract” method.

- Some subclass must override because there is no definition in base class
- Makes sense with dynamic dispatch
- Unlike Java, no need/way to mark the class specially
- Funny syntax in base class; override as usual:

```
class C {  
    virtual t0 m(t1, t2, ..., tn) = 0;  
    ...  
};
```

- Side-comment: with multiple inheritance and pure-virtual methods, no need for a separate notion of Java-style interfaces

# C++ summary

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- Lots of new syntax and gotchas, but just a few new concepts:
  - Objects vs. pointers to objects
  - Destructors
  - virtual vs. non-virtual
  - pass-by-reference
  - Plus all the stuff we didn't get to, especially templates, exceptions, and operator overloading.
  - Later (if time): why objects are better than code-pointers – coding up object-like idioms in C