

# COMP110: Principles of Computing

## Smart Pointers

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- ▶ In particular, responsibility for the **lifetime** of object instances, i.e. remembering to call `delete` at the right time
- ▶ C++11 introduced **smart pointers** to try and make this easier

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- ▶ `std::unique_ptr` has **sole ownership** of the instance to which it points
- ▶ I.e. two `unique_ptr`s **cannot** point to the same instance
- ▶ Use `std::make_unique<T>` instead of `new T`
- ▶ The instance is destroyed when the `unique_ptr` goes **out of scope**, or when it is assigned to point to a different instance

# Unique pointer example

```
#include "stdafx.h" // --> #include <memory>

class MyClass { };

int main()
{
    std::unique_ptr<MyClass> p
        = std::make_unique<MyClass>();
    return 0;
    // p is automatically deleted here
}
```

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- ▶ Careful — this can make your code **more readable** or **less readable** depending on how and where you use it!

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But now:

- ▶ `std::vector<std::unique_ptr<Duck>>`: class instances stay put, but are automatically destroyed when removed from the `vector`!

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auto q = p;
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- ▶ Translation: assigning one `unique_ptr` from another is forbidden

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# Unique pointers can be moved

```
auto p = std::make_unique<MyClass>();  
auto q = std::move(p);
```

- ▶ Now `q` has **ownership** of the instance
- ▶ `p` no longer refers to this instance
- ▶ In fact `p` becomes null
- ▶ Another way you are allowed to move `unique_ptr`s is by **swapping**:

```
auto p = std::make_unique<MyClass>("hello");  
auto q = std::make_unique<MyClass>("world");  
std::swap(p, q);
```

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- ▶ C++ also has `std::shared_ptr`, which does allow multiple pointers to the same instance
- ▶ **Reference counting** ensures the instance is destroyed when **all** `shared_ptr`s to it have gone away (and not before!)

```
int main()
{
    bool flag = true;
    std::shared_ptr<MyClass> p = nullptr;

    if (flag)
    {
        auto q = std::make_shared<MyClass>();
        p = q;
    }
    /* q is out of scope, but p still holds a ↵
       reference to the instance so it stays alive */

    if (p)
        p->doSomething();

    return 0;
    /* p is out of scope now, so the instance is ↵
       destroyed */
}
```



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- ▶ When the reference count is decremented to 0, the instance is destroyed

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  - ▶ `shared_ptr` decrements the reference count on the instance to which it points, which may result in it being destroyed
- ▶ ... just as you would expect (hopefully)!

```
class Duck
{
public:
    Duck(const std::shared_ptr<Pond>& pond)
        : pond(pond),
          bill(std::make_unique<Bill>())
    { }

private:
    std::unique_ptr<Bill> bill;
    std::shared_ptr<Pond> pond;
};
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When a `Duck` instance is destroyed:

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- ▶ Its `Bill` is also destroyed;

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```

When a `Duck` instance is destroyed:

- ▶ Its `Bill` is also destroyed;
- ▶ Its `Pond` is destroyed **if and only if** there are no other `shared_ptr`s to it (e.g. in other `Duck` instances)

```
class Bar;

class Foo
{
public:
    std::shared_ptr<Bar> bar;
};

class Bar
{
public:
    std::shared_ptr<Foo> foo;
};

int main()
{
    auto p = std::make_shared<Foo>();
    p->bar = std::make_shared<Bar>();
    p->bar->foo = p;
}
```

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- ▶ In the example on the previous slide, the instances are **not** destroyed properly at the end of `main()`
- ▶ `Foo` still holds a reference to `Bar`, but `Bar` holds a reference to `Foo`
- ▶ This prevents both objects' reference counts from reaching 0
- ▶ Solution: make one of the references a **weak pointer**

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```
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- ▶ Locking creates a temporary `shared_ptr` to the instance — this ensures that the reference count stays above 0 while the instance is being used

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- ▶ `std::weak_ptr` is useful for breaking **reference cycles** when using `shared_ptr`s for composition
- ▶ `std::unique_ptr` can be used when you want to enforce that there is **only one** pointer to a particular instance
- ▶ NB: all smart pointer types allow **polymorphism**, e.g.

```
class Bird {};  
class Duck : public Bird {};  
  
std::shared_ptr<Bird> bird = std::make_unique<Duck>();
```

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  - ▶ Because sometimes you need to use them, e.g. when working with SDL or other APIs / libraries
  - ▶ Because once you can write a nontrivial program that uses pointers and doesn't crash or leak memory, you can call yourself a Real Programmer ☺

# Reminders



# This Wednesday (9th March)

Your proposal for **COMP110 Coding Task 2** is due **in the lecture**

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Your A\* pathfinding program for **COMP110 Worksheet 5** is due **by 6pm**

- ▶ Submit a pull request on GitHub
- ▶ Book a tutor meeting to discuss and sign off