CONSTRUCTORS

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4.1 CLASSES AND OBJECTS

Classes are custom data types in C++—describing data organization and operations

```
class Point {
    int x, y; // data organization
public:
    void set(int ix, int iy) { // operations
        x = ix;
        y = iy;
    }
};
```

4.1 CLASSES AND OBJECTS

Objects are entities of classes

Variables are entities of basic types

```
int a = 3; // basic type variable
struct Date { // structure variable
    int year, month, day;
};
Point w;
w.set(3, 5);
```

4.1 CLASSES AND OBJECTS

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C++ IS A HYBRID PROGRAMMING LANGUAGE

- Simple data structures, pure compound control statements, function (module) design, forming procedural programming
- Based on classes and objects, with procedural programming as the framework, forming object-oriented programming
- Based on class hierarchy polymorphism as the main object of data processing, with object-oriented design as the framework, forming object-oriented programming

4.2 THE NECESSITY OF CONSTRUCTORS

All data entities have an initialization requirement

```
int a = 3;      // Integer variable initialization
int a; a = 3;   // Integer variable assignment
double t[] = {1.3, 2.5}; // Array initialization
struct Date {int year, month, day; };
Date d = {1998, 5, 23}; // Structure variable initialization
```

4.2 THE NECESSITY OF CONSTRUCTORS

For objects, initialization is a complex problem

```
class Point {
    int x, y;
public:
    void set(int ix, int iy) {
        x = ix;
        y = iy;
    }
};
int main() {
    // Error, directly assigning to private variables
    Point t = {3, 4};
    Point d; // Produces an uninitialized object
    d.set(3, 4); // Assign values, not initialization
}
```

4.2 THE NECESSITY OF CONSTRUCTORS

If all variables are public, you can do this:

```
1 class Point {
2 public:
3     int x, y;
4 };
5
6 int main() {
7     Point t = {3, 4};
8     return 0;
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4.3 USING CONSTRUCTORS

The design of object initialization

Should be completed during object construction, regardless of access permissions

```
class A {
    int a, b;
};
A x = {2, 3}; // OK
A y{2, 3}; // OK
A z(2, 3); // OK
```

4.3 USING CONSTRUCTORS

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```
1 class A {
2     int a, b;
3 public:
4     void A(int ia, int ib); // Wrong
5     construct(int ia, int ib); // Wrong
6     A(int ia, int ib); // Right
7 };
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```

4.3 USING CONSTRUCTORS

Example: Adding a constructor to the `Clock` class

```
class Clock {
    int hour, minute, second;
public:
    Clock(int h, int m, int s) {
        ...
    }
};
```

4.3 USING CONSTRUCTORS

Implementing Constructors: Initializing Member Variables

```
Clock(int h, int m, int s) {
    hour = h;
    minute = m;
    second = s;
}
```

4.3 USING CONSTRUCTORS

Implementing Constructors: Initializing Member Variables

```
Clock(int h, int m, int s) : hour(h), minute(m), second(s) {}
```

4.3 USING CONSTRUCTORS

Constructor Call:

```
 1 class Desk {
 2 public:
 3     Desk();
 4 private:
 5     int height, width;
 6 };
 7
 8 Desk::Desk() {
 9     cout << "Constructor of Desk." << endl;
10     height = 3;
11     width = 2;
12 }
13
14 Desk desk; // call the constructor
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4.4 DESTRUCTORS

In class design, if there is a pointer member, the constructor will allocate heap memory and assign it to the pointer, allowing member functions to share the resource

```
class A {
    int* aa;
    int num;
public:
    A(int n) {
        num = n;
        aa = new int[n];
        // delete[] aa; ???
    }
};
```

4.4 DESTRUCTORS

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- Sometimes when we release a class object, we may need to do some cleanup work, but we may also encounter problems due to forgetting to call these cleanup functions. How can we solve this?
- C++ also considers this for us. Opposite to the constructor, it provides a destructor specifically for handling cleanup work when an object is destroyed.

4.4 DESTRUCTORS

- Destructors have no return type, no parameters, and the function name is the class name prefixed with "~". Destructors will be automatically called when the object's lifespan ends.
- Destructors can also be private, although this is uncommon.

4.4 DESTRUCTORS

```
 1 class A {
 2     int* aa;
 3     int num;
 4 public:
 5     A(int n) {
 6         num = n;
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 9     ~A() { // Cannot have parameters
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12 };
```

4.5 CONSTRUCTORS WITH PARAMETERS

By passing parameters to the constructor, you can specify the values of member variables.

```
class Student {
    std::string name;
    char gender;
    double gpa;
public:
    Student(const std::string& name, char gender, double gpa):
    name(name), gender(gender), gpa(gpa) {}
};

Student stu("Eric", 'M', 4.5);
```

4.5 CONSTRUCTORS WITH PARAMETERS

```
 1 class Teacher {
 2     std::string name;
 3     uint8_t age;
 4 public:
 5     Teacher(const std::string& name, uint8_t age) {
 6         this→name = name;
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To abandon this feature, you can do this:

```
class A{
    int a;
public:
    explicit A(int n):a(n){} // 注意新的关键字
};

int main() {
    A a = 1; // Wrong
    return 0;
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- Generally speaking, `const char*` is more performant but less safe.
- Most of the time, it's unnecessary to consider performance to this extreme.
- In most cases, choose `const std::string&`.
- After `c++17`, you can use `std::string_view`.

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- Sometimes, when the constructor parameters have the same name as the member variables, you can:
  - Use the `this` pointer
  - Use the member initialization list
- The `this` pointer is an implicit pointer in class member functions that points to the current object instance, used to access the object's members.

4.5 CONSTRUCTORS WITH PARAMETERS

```
class Point {
    int x, y;
public:
    Point(int x, int y) : x(x), y(y) {}
};
```

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class Point {
    int x, y;
public:
    Point(int x, int y){
        this→x = x;
        this→y = y;
    }
};
```

4.5 CONSTRUCTORS WITH PARAMETERS

The following two ways to call constructors are equivalent:

```
Point p(3, 4); // Traditional way
// If the constructor is explicit, compilation will fail
Point p = {3, 4};
// Recommended way, after C++11,
// distinguishes from function calls
Point p{3, 4};
```

4.6 OVERLOADING CONSTRUCTORS

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- A class can provide multiple constructors, i.e., constructor overloading.
- The purpose of overloading is to meet different initialization needs.

4.6 OVERLOADING CONSTRUCTORS

```
 1 class Clock
 2 {
 3 private:
 4     int hour, minute, second;
 5 public:
 6     Clock(int h, int m, int s);
 7     Clock();
 8     Clock(const std::string& timestr);
 9 };
10
11 int main( )
12 {
13     Clock clock1{23, 12, 0};
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4.6 OVERLOADING CONSTRUCTORS

How to implement a class with multiple construction methods?

```
int main()
{
    Date date1{2000, 3, 4};
    Date date2{2000, 3};
    Date date3{2000};
    Date date4{};
    return 0;
}
```

4.6 OVERLOADING CONSTRUCTORS

SCHEME 1 (OVERLOADING)

```
class Date{
  int year, month, day;    // default private
public:
  // The following four overloaded functions,
  // each corresponding to a way to build an object
  Date();
  Date(int d);
  Date(int m, int d);
  Date(int y, int m, int d);
};
Date::Date(){ year=1900; month=1; day=1; }
Date::Date(int y){ month=4; day=d; year=1996; }
Date::Date(int y, int m){ month=m; day=1; year=1900; }
Date::Date(int y, int m, int d){ month=m; day=d; year=y; }
```

4.6 OVERLOADING CONSTRUCTORS

SCHEME 2 (C++11)

```
class Date {
    int year, month, day;
public:
    Date(int year, int month, int day)
      : year(year), month(month), day(day) {}
    Date(int year, int month) : Date(year, month, 1) {}
    Date(int year) : Date(year, 1, 1) {}
    Date() : Date(1900, 1, 1) {}
};
```

4.6 OVERLOADING CONSTRUCTORS

SCHEME 3 (DEFAULT PARAMETERS, RECOMMENDED)

```
class Date
{
    int year, month, day;
public:
    Date(int year = 1900, int month = 1, int day = 1)
        : year(year), month(month), day(day)
    {
    }
};
```

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- The default constructor must be a parameterless constructor, and the parameterless constructor can be customized
- In fact, there is also a corresponding default destructor that exists

4.7 DEFAULT CONSTRUCTORS

```
 1 class Date
 2 {
 3 };
 4
 5 int main()
 6 {
 7     Date date{}; // ok
 8     Date date2; // ok
 9     // Date date3(); // wrong
10     return 0;
11 }
```

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- Constructors always create object space first, then execute constructor body statements
- If the class contains object members, when the constructor creates object space, it calls the default constructor of the object member, then executes the constructor body statements
- If object members do not have a default constructor, use the member initialization list method

4.8 CLASS MEMBER INITIALIZATION

```
 1 class Teacher {
 2     std::string name;
 3     uint8_t age;
 4 public:
 5     Teacher(const std::string& name, uint8_t age) {
 6         this->name = name;
 7         this->age = age;
 8     }
 9 };
10
11 class Student {
12     std::string name;
13     char gender;
14     double gpa;
15     Teacher t;
```

4.8 CLASS MEMBER INITIALIZATION

```
 1 class Teacher {
 2     std::string name;
 3     uint8_t age;
 4 public:
 5     Teacher(const std::string& name, uint8_t age) {
 6         this->name = name;
 7         this->age = age;
 8     }
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```

4.9 ORDER OF OBJECT CONSTRUCTION

Members are constructed in the order they are declared in the class

```
class A {
    int num, age; // First construct num, then construct age
public:
    // The order here does not matter
    A(int n) : age(n), num(age + 1) {}
};
```

EXAMPLE: JOSEPHUS PROBLEM