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:

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

int main() {
    Point t = {3, 4};
    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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```
class A {
    int a, b;
public:
    void A(int ia, int ib); // Wrong
    construct(int ia, int ib); // Wrong
    A(int ia, int ib); // Right
};
```

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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:

```cpp
class Desk {
public:
    Desk();
private:
    int height, width;
};

Desk::Desk() {
    cout << "Constructor of Desk." << endl;
    height = 3;
    width = 2;
}

Desk desk; // call the constructor
```

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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; ???
    }
};
```

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- 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

```cpp
class A {
    int* aa;
    int num;
public:
    A(int n) {
        num = n;
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    ~A() { // Cannot have parameters
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};
```

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4.5 CONSTRUCTORS WITH PARAMETERS

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

```cpp
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

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class Teacher {
    std::string name;
    uint8_t age;
public:
    Teacher(const std::string& name, uint8_t age) {
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```
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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- 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.

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```cpp
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:

```cpp
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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- C++ member functions can be overloaded, and constructors can also be overloaded
- A class can provide multiple constructors, i.e., constructor overloading.
- The purpose of overloading is to meet different initialization needs.

4.6 OVERLOADING CONSTRUCTORS

```
class Clock
{
private:
    int hour, minute, second;
public:
    Clock(int h, int m, int s);
    Clock();
    Clock(const std::string& timestr);
};

int main( )
{
    Clock clock1{23, 12, 0};
    Clock clock2{};
    Clock clock3{“14:45:32”};
```

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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)

```cpp
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

```cpp
class Date
{
};

int main()
{
    Date date{}; // ok
    Date date2; // ok
    Date date3(); // ok
    return 0;
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- 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

```cpp
class Teacher {
    std::string name;
    uint8_t age;
public:
    Teacher(const std::string& name, uint8_t age) {
        this->name = name;
        this->age = age;
    }
};

class Student {
    std::string name;
    char gender;
    double gpa;
    Teacher t;
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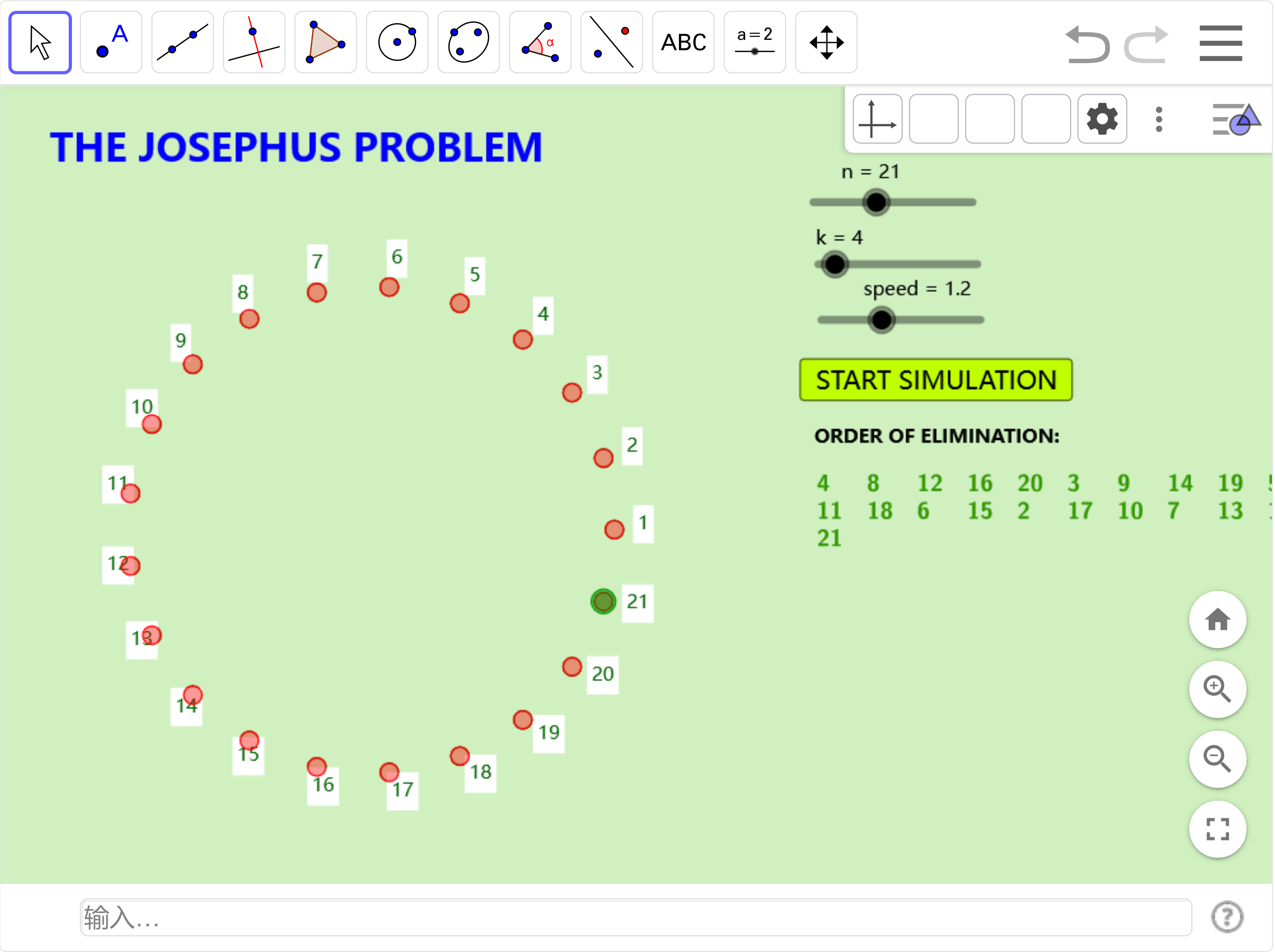
```cpp
class Teacher {
    std::string name;
    uint8_t age;
public:
    Teacher(const std::string& name, uint8_t age) {
        this->name = name;
        this->age = age;
    }
};

class Student {
    std::string name;
    char gender;
    double gpa;
    Teacher t;
```

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



THE JOSEPHUS PROBLEM

n = 21

k = 4

speed = 1.2

START SIMULATION

ORDER OF ELIMINATION:

```
4    8    12   16   20   3    9    14   19   5
11   18   6    15   2    17   10   7    13
21
```