Chapter 6. Struct and Classes

Programming Concepts in Scientific Computing

EPFL, Master class

October 18, 2023

Types

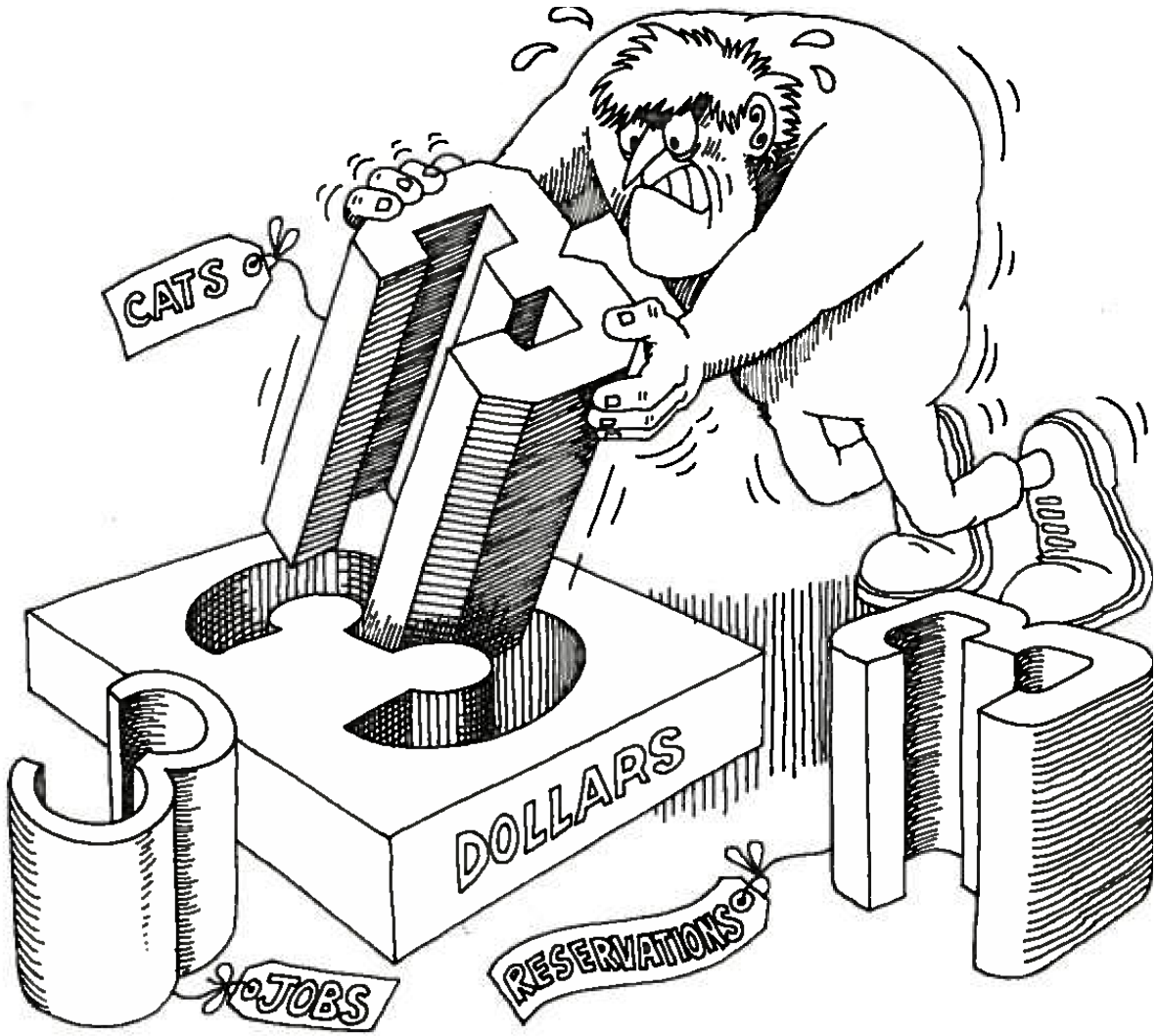
Known types

- void
- char
- short
- int
- long int
- float
- double
- long double
- pointers

Specifiers

- unsigned
- const

Types



How to define new types ?

New types

How ?

```
struct NameType {
  double a;
  int b;
};
```

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Structures

Example

Definition

```
struct Planet {
  double coords[3];
  std::string name;
};
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Creating a variable

```
Planet p;
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Structures

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Creating a variable

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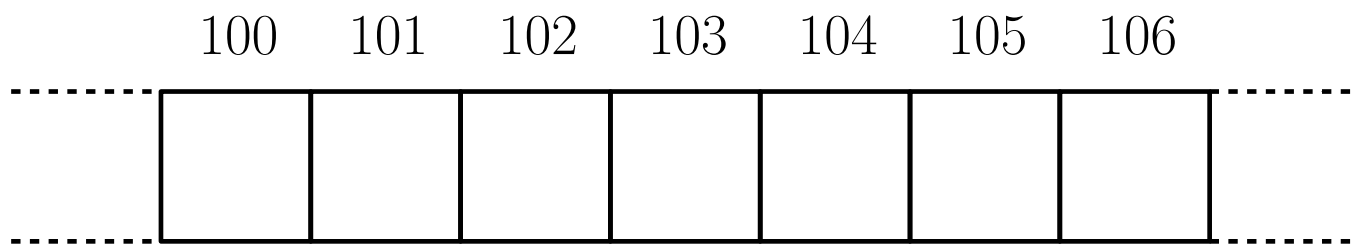
How is the memory representation ?



Structures

Example

How to access the variables of a structure

```
Planet p;
p.coords[0] = 10;
```

Structures

Example

How to access the variables of a structure

```
Planet p;
p.coords[0] = 10;
```

How to get the size of a structure (in bytes)

```
std::cout << sizeof(Planet) << std::endl;
```

What is a class ?

What is a class ?

A type associating
Data and **Functions**

A blue print to fabricate **Objects**

Objects

What is an object ?

Objects

What is an object ?

An **instanciation**(variable)
of a **class**/**struct** type

Classes

Gathering data and functions

```
struct Planet {
  void move(double delta[3]);
  double coords[3];
};
```

Classes

Gathering data and functions

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struct Planet {
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Vocabulary

- variables (state): members
- functions: methods

Classes

Gathering data and functions

```
struct Planet {
  void move(double delta[3]);
  double coords[3];
};
```

Vocabulary

- variables (state): members
- functions: methods

Usage:

```
p.move(delta);
```

Classes

```
Planet p;
p.move(delta);
```

Can be done in C with multiple files (modules) ?

Classes

```
Planet p;
p.move(delta);
```

Can be done in C with multiple files (modules) ?

```
move_c_style(p, delta);
```

Classes

Encapsulation

```
class Planet {

public:
  Planet();                          // constructor
  ~Planet();                         // destructor
  void move(double delta[3]); // a method

private:
  double coords[3]; // a member
};
```

Classes

Encapsulation

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Classes

Encapsulation

```
class Planet {

public:
  Planet();                          // constructor
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```

- It is an interface (declaration in a .hh/.hpp file)

Classes

Encapsulation

```
class Planet {

public:
  Planet();                          // constructor
  ~Planet();                         // destructor
  void move(double delta[3]); // a method

private:
  double coords[3]; // a member
};
```

- It is an interface (declaration in a .hh/.hpp file)
- Methods and members are accessible/inaccessible

Classes

Methods definitions (.cpp/.cpp)

```
#include "planet.hh"

void Planet::move(double delta[3]) {
  // DO SOME CODE
}
```

Classes

Methods definitions (.cpp/.cpp)

```
#include "planet.hh"

void Planet::move(double delta[3]) {
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Classes

Construction/Destruction

Constructor: set the initial state

```
Planet::Planet() {
  coords[0] = 0.;
  coords[1] = 1.;
  coords[2] = 2.;
}
```

Classes

Construction/Destruction

Constructor: set the initial state

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Planet::Planet() {
  coords[0] = 0.;
  coords[1] = 1.;
  coords[2] = 2.;
}
```

Destructor

```
Planet::~Planet() {}
```

Classes

Construction/Destruction

Constructor: set the initial state

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Planet::Planet() {
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Destructor

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Planet::~Planet() {}
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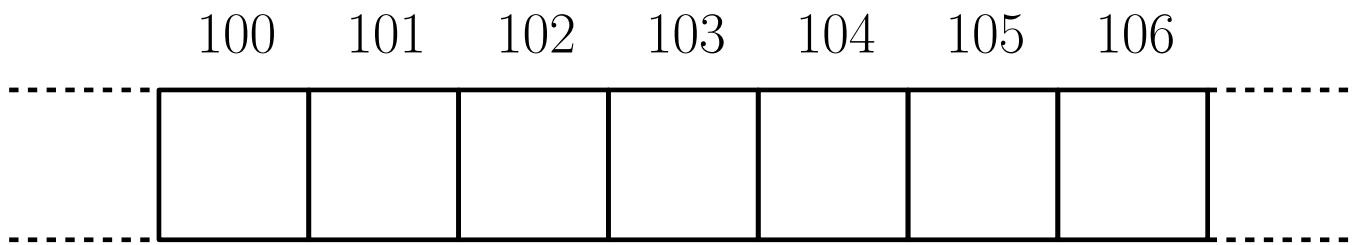
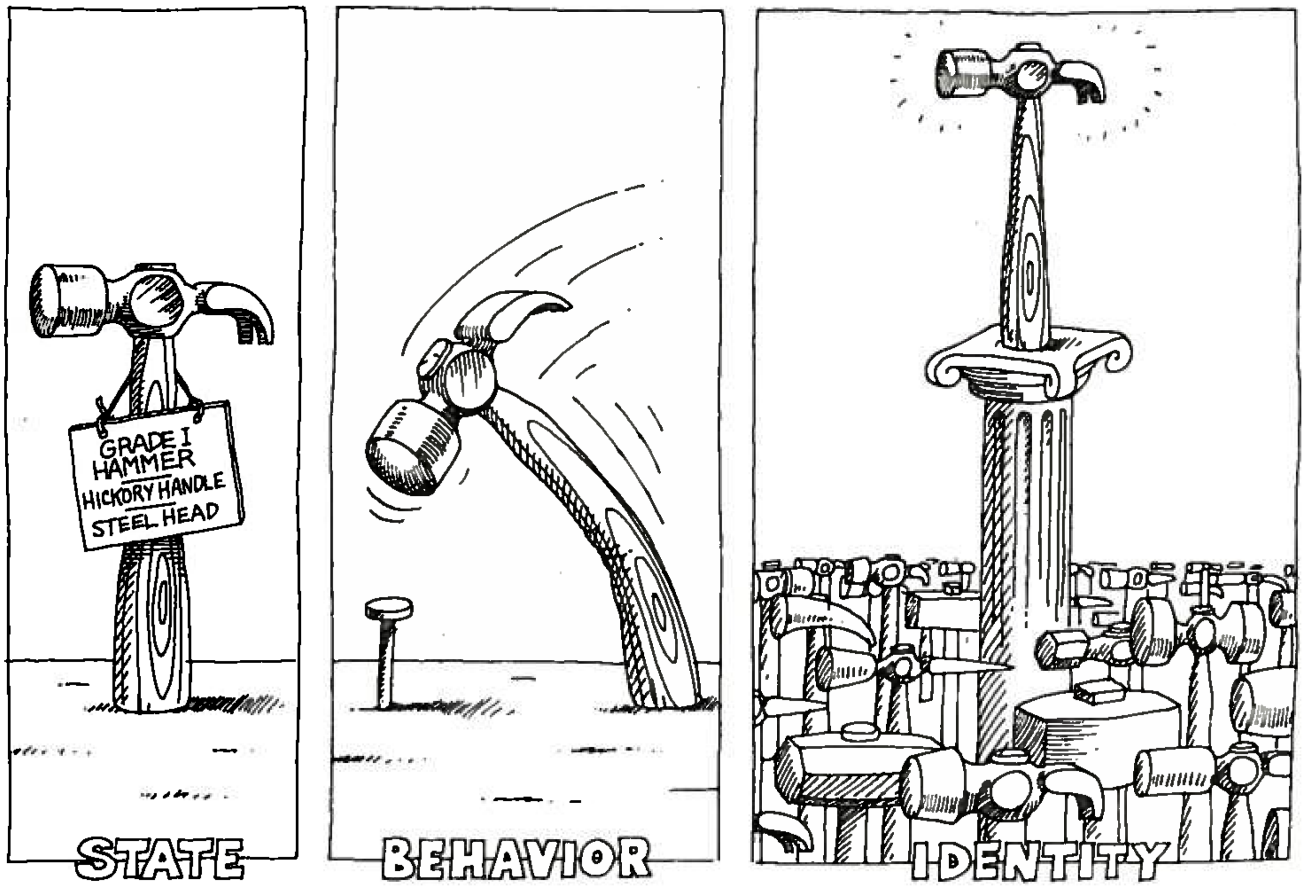


Classes&Objects



Classes

Constructor/Destructor

- Constructor sets the initial state
- Destructors release memory allocations

```
class Planet {

public:
  Planet();                          // constructor
  ~Planet();                         // destructor
  void move(double delta[3]); // a method

private:
  // a pointer member
    double *coords;
};
```

Classes

Constructor/Destructor

```
Planet::Planet() {
    coords = new double[3];
  coords[0] = 0.;
  coords[1] = 1.;
  coords[2] = 2.;
}


Planet::~Planet() {
  // delete memory
    delete[] coords;
}
```

Classes

Constructor with parameter(s)

```
class Planet {

public:
  Planet();                                  // constructor
  Planet(double param1, int param2);
  Planet(const Planet &);                    // copy constructor
  ~Planet();                                 // destructor
  void move(double delta[3]);                // a method

private:
  // a pointer member
  double *coords;
};
```

Classes

Constructor with parameter(s)

```
class Planet {

public:
  Planet();                                  // constructor
  Planet(double param1, int param2); // second constructor
  Planet(const Planet &);                        // copy co
  ~Planet();                                 // destructor
  void move(double delta[3]);                // a method

private:
  // a pointer member
  double *coords;
};
```

Classes

Copy constructor

```
Planet::Planet(const Planet &p) {

  // copy pointer ?
  coords = p.coords;
```

Classes

Copy constructor

```
Planet::Planet(const Planet &p) {

  // copy pointer ?
  coords = p.coords;

  // or copy the content ?
  coords = new double[3];
  for (int i = 0; i < 3; ++i) {
    coords[i] = p.coords[i];
  }
}
```

Objects

Pointer/reference to object

```
Planet p;
Planet *ptr = &p;
Planet &ref = p;
```

Objects

Pointer/reference to object

```
Planet p;
Planet *ptr = &p;
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Dynamically allocate an object

```
Planet *p1 = new Planet; // no parentheses!
Planet *p2 = new Planet(param1, param2);
```

Objects

Pointer/reference to object

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Planet p;
Planet *ptr = &p;
Planet &ref = p;
```

Dynamically allocate an object

```
Planet *p1 = new Planet; // no parentheses!
Planet *p2 = new Planet(param1, param2);
```

```
p1->move(coords);
```

Objects

this pointer

What is the mysterious **this** ?

```
struct Planet {

  void test() { std::cout << this << std::endl; }
};

int main() {
  Planet p;
  std::cout << &p << std::endl;
  p.test();
}
```

Objects

this pointer

What is the mysterious **this** ?

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struct Planet {

  void test() { std::cout << this << std::endl; }
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int main() {
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}
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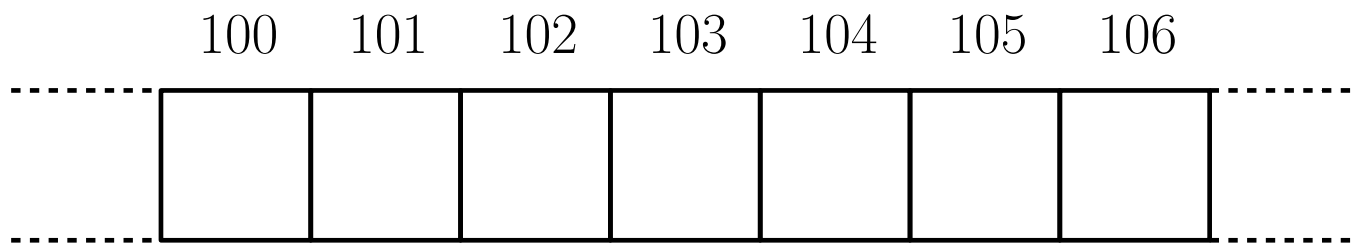

Classes friends

What happens if we do this ? (try it)

```
class A {

private:
  int secret;
};

class B {
  int getSecret(A &a) { return a.secret; }
};
```

Classes friends

```
class A {

private:
   friend B;
  int secret;
};

class B {
  int getSecret(A &a) { return a.secret; }
};
```

Classes friends

```
class A {

private:
   friend int toto(A &a);
  int secret;
};

int toto(A &a) { return a.secret; }
```

Class operators

```
class A {
public:
  int operator[](int i) {
    // modifies the behavior
    return values[i] * 2;
  }

private:
  int values[100];
};
```

Class operators

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class A {
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Class operators

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class A {
public:
  int operator[](int i) {
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    return values[i] * 2;
  }

private:
  int values[100];
};
```

You defined the operator [.]

```
std::cout << a[2] << std::endl;
```

Const in methods

```
class A {
public:
  int doItConst() const {

    values[0] = 2; // error: cannot touch the members

    return values[0];
  }

private:
  int values[100];
};
```

Class

Take away message

- **Class**: A type associating **Data** and **Functions**
- **Object/Instance**: A variable of a **class**/**struct** type
- **Methods**: Functions in a class
- **Members**: Variables in a class
- **Encapsulation**: mechanism allowing **public** and **private** sections
- **Operators**: special functions to define operators ()[]*-/+ etc.
- **this**: pointer to current object