

POINTERS TO OBJECTS

Objects are stored in memory, so pointers can point to objects just as they can to variables of basic types.

The new Operator:

The new operator allocates memory of a specific size from the operating system and returns a pointer to its starting point. If it is unable to find space, it returns a 0 pointer.

When you use new with objects, it does not only allocate memory for the object, it also *creates* the object in the sense of invoking the object's constructor. This guarantees that the object is correctly initialized, which is vital for avoiding programming errors.

The delete Operator:

To ensure safe and efficient use of memory, the new operator is matched by a corresponding delete operator that releases the memory back to the operating system.

If you create an array with new Type[];, you need the brackets when you delete it:

```
int * ptr = new int[10];
```

```
:
```

```
delete [ ] ptr;
```

Don't forget the brackets when deleting arrays of objects. Using them ensures that all the members of the array are deleted and that the destructor is called for each one. If you forget the brackets, only the first element of the array will be deleted.

Example:

```

class String{
    int size;
    char *contents;
public:
    String(); // Default constructor
    String(const char *); // Constructor
    String(const String &); // Copy constructor
    const String& operator=(const String &); // Assignment operator
    void print() const ;
    ~String(); // Destructor
};

int main()
{
    String *sptr = new String[3]; // Creates 3 objects
    String s1("String_1"); // A String object
    String s2("String_2"); // Another String object
    *sptr = s1; // First element of the array
    *(sptr + 1) = s2; // Second element of the array
    sptr->print(); // Prints the first element
    (sptr+1)->print(); // Prints the second element
    sptr[1].print(); // Prints the second element
    delete[] sptr; // Objects pointed by sptr are deleted
    return 0;
}

```

See Example: e71.cpp

Linked List of Objects

A class may contain a pointer to objects of its type. This pointer can be used to build a chain of objects, a linked list.

```
class Teacher{
    friend class Teacher_list;
    string name;
    int age, numOfStudents;
    Teacher * next;           // Pointer to next object of teacher
public:
    Teacher(const string &, int, int); // Constructor
    void print() const;
    const string& getName() const {return name;}
    ~Teacher()           // Destructor
};
```

```
// linked list for teachers
class Teacher_list{
    Teacher *head;
public:
    Teacher_list(){head=0;}
    bool append(const string &,int,int);
    bool del(const string &);
    void print() const ;
    ~Teacher_list();
};
```

See Example: e72.cpp

In the previous example the Teacher class must have a pointer to the next object and the list class must be declared as a friend, to enable users of this class building linked lists.

If this class is written by the same group then it is possible to put such a pointer in the class. But usually programmers use ready classes, written by other groups, for example classes from libraries. And these classes may not have a next pointer. To build linked lists of such ready classes the programmer have to define a node class. Each object of the node class will hold the addresses of an element of the list.

```
class Teacher_node{
    friend class Teacher_list;
    Teacher * element;           // The element of the list
    Teacher_node * next;        // next node
    Teacher_node(const string &, int, int); // constructor
    ~Teacher_node();            // destructor
};

Teacher_node::Teacher_node(const string & n, int a, int nos){
    element = new Teacher(n, a, nos);
    next = 0;
}

Teacher_node::~~Teacher_node(){
    delete element;
}
```

See Example: e73.cpp

Pointers and Inheritance

If a class Derived has a public base class Base, then a pointer to Derived can be assigned to a variable of type pointer to Base without use of explicit type conversion. A pointer to Base can carry the address of an object of Derived. The opposite conversion, for pointer to Base to pointer to Derived, must be explicit.

For example, a pointer to Teacher can point to objects of Teacher and to objects of Principal. A principal is a teacher, but a teacher is not always a principal.

```
class Base{  
};
```

```
class Derived : public Base {  
};
```

```
Derived d;  
Base *bp = &d;  
Derived *dp = bp;  
dp = static_cast<Derived *>(bp);
```

```
// implicit conversion  
// ERROR! Base is not Derived  
// explicit conversion
```

If the class Base is a **private** base of Derived , then the implicit conversion of a Derived* to Base* would not be done. Because, in this case a public member of Base can be accessed through a pointer to Base but not through a pointer to Derived.

```
class Base{
    int m1;
    public:
        int m2;                // m2 is a public member of Base
};
```

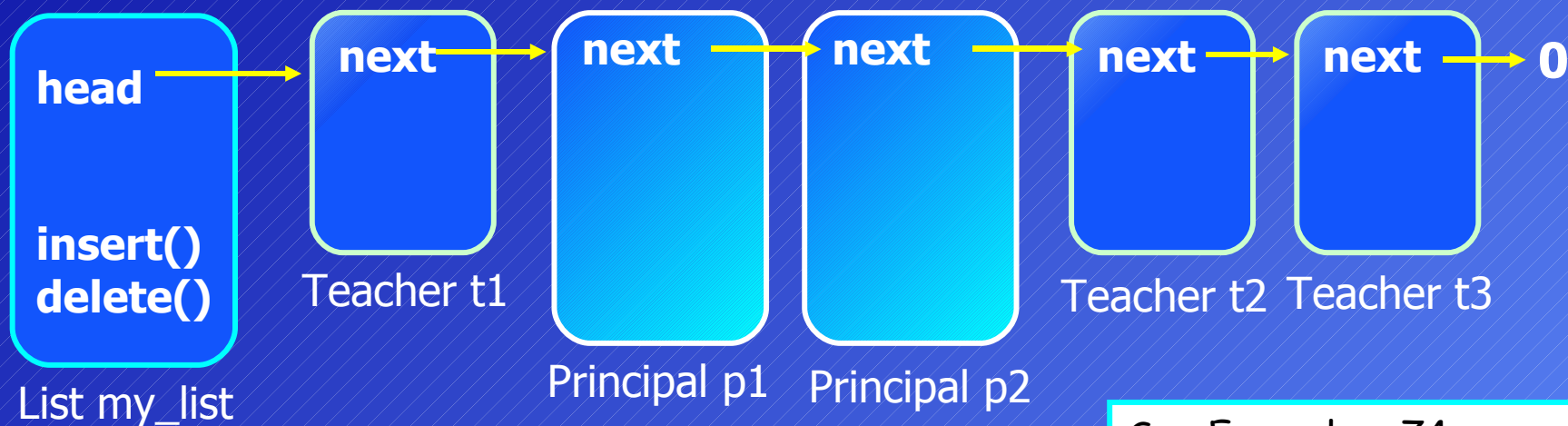
```
class Derived : private Base {    // m2 is not a public member of Derived
:
};
```

```
Derived d;
d.m2 = 5;                // ERROR! m2 is private member of Derived
Base *bp = &d;           // ERROR! private base
bp = static_cast<Base*>(&d); // ok: explicit conversion
bp->m2 = 5;              // ok
```


Heterogeneous Linked Lists

Using the inheritance and pointers, **heterogeneous** linked lists can be created. A list specified in terms of pointers to a base class can hold objects of any class derived from this base class. We will discuss heterogeneous lists again, after we have learnt polymorphism.

Example: A list of teachers and principals



See Example: e74.cpp

There is a **list** class in the Standard Template Library (STL) of the C++. You don't need to write classes to build linked lists. You can use the list class of the library.