04: Class and Object Manipulations

Programming Technique II
(SCSJ1023)

Adapted from Tony Gaddis and Barret Krupnow (2016), Starting out with C++: From Control Structures through Objects

Friends of Classes

Friends of Classes

- **Friend**: a function or class that is not a member of a class, but has access to private members of the class

- A friend function can be a stand-alone function or a member function of another class

- It is declared a friend of a class with **`friend`** keyword in the function prototype

Friends of Classes

- Stand-alone function:

```
friend void setAVal(intVal&, int);
// declares setAVal function to be
// a friend of this class
```

- Member function of another class:

```
friend void SomeClass::setNum(int num)
// setNum function from SomeClass
// class is a friend of this class
```

Friends of Classes

- Class as a friend of a class:

```
class FriendClass
{
  . . .
};
class NewClass
{
 public:
    friend class FriendClass;
   // declares entire class as a friend
   //  of this claFriendClass ss
 ...
};
```

Pointers to Objects

Pointers to Objects

- You can declare a pointer to an object:

```
Rectangle *rPtr;
```

Declaring a pointer which can only point to an object of `Rectangle`

- Then, you can access public members via the pointer:

```
rPtr = &otherRectangle;
rPtr->setLength(12.5);
(*rPtr).setLength(12.5);
cout << rPtr->getLenght() << endl;
```

`rPtr` is now pointing to the object `otherRectangle`

two types of syntax to access object's members via pointer.

Pointers to Objects

Revisit the concept:

- A variable is meant to contain or hold a value.
- A **pointer** is meant to point to a variable (not to contain value).
  - Declaring a pointer does not create an object. Thus, no constructor is executed.

- Example:

```
Rectangle *p;
Rectangle r;
```

`p` is not an object but a pointer. No object is created here. Thus no constructor is executed.

`r` is an object of class `Rectangle`. The default constructor is executed here.

Pointers to Objects

- The following declaration does not work: why?

```
Rectangle *p();
```

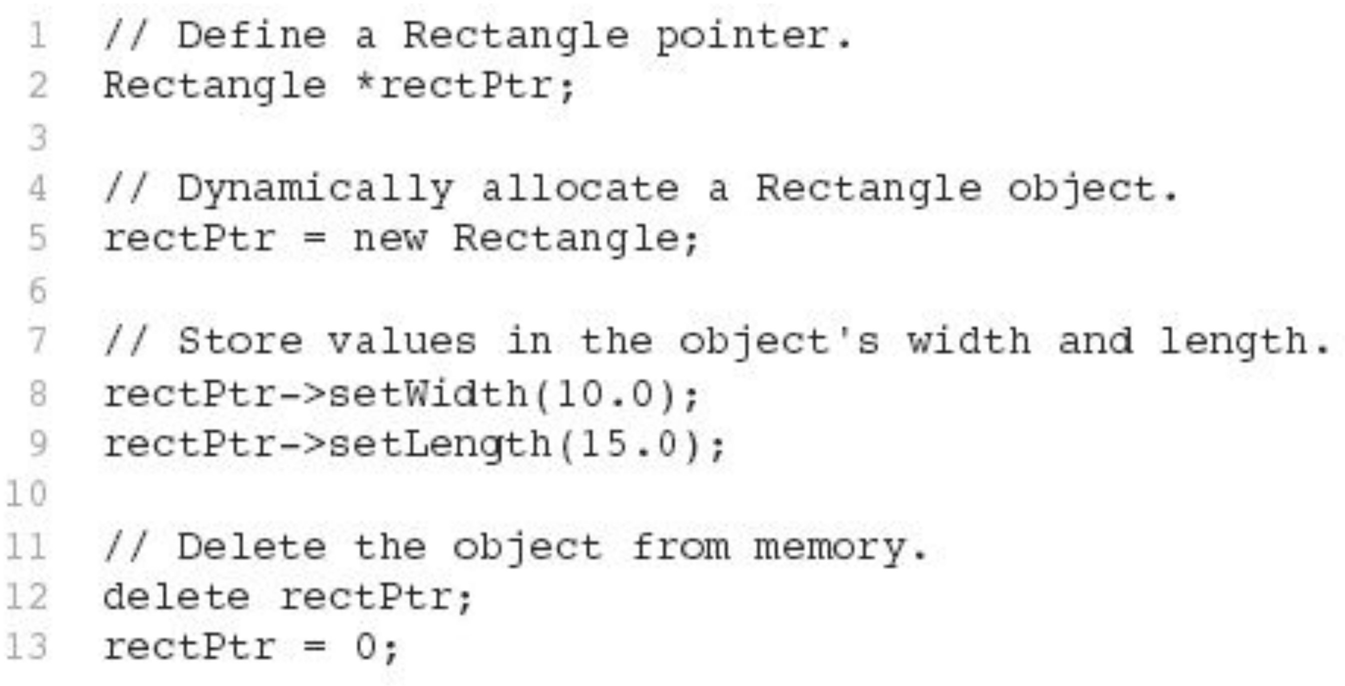
you may think of that a default constructor will be executed here. **Wrong!** A pointer does not have a constructor, only objects have.

In fact, the compiler assumes this code as a function prototype named `p()` which returns a pointer of type `Rectangle` i.e.

```
Rectangle* p();
```

Dynamically Allocating an Object

We can also use a **pointer** to **dynamically allocate an object**.



```
// Define a Rectangle pointer.
Rectangle *rectPtr;

// Dynamically allocate a Rectangle object.
rectPtr = new Rectangle;

// Store values in the object's width and length.
rectPtr->setWidth(10.0);
rectPtr->setLength(15.0);

// Delete the object from memory.
delete rectPtr;
rectPtr = 0;
```

Arrays of Objects

Arrays of Objects

```
class InventoryItem {
   private:
      char *description;  double cost; int units;
   public:
      InventoryItem();
      InventoryItem(const char desc[]);
      InventoryItem(const char desc[],double c, int
u);
     ~InventoryItem();
     :
}; // end of class declaration
```

- Objects can be the elements of an array:

  `InventoryItem inventory[40];`

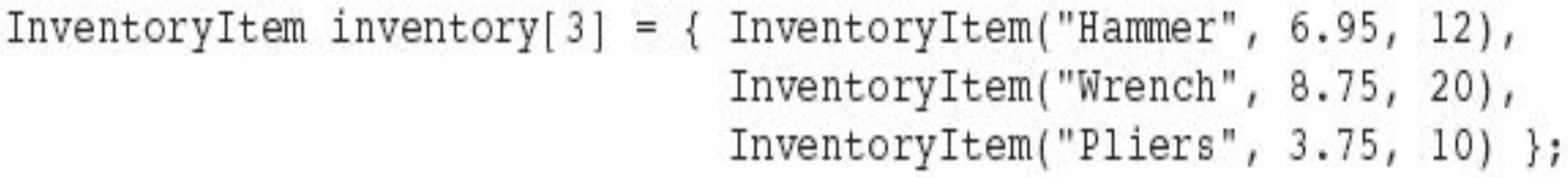
- **Default constructor** for object is used when **array is defined**

Arrays of Objects

- Must use initializer list to invoke constructor that takes arguments:

```
InventoryItem inventory[3] =
{"Hammer", "Wrench", "Pliers"};.
```

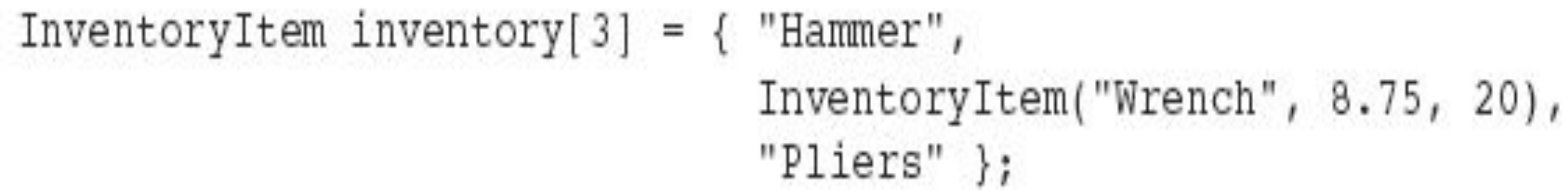
- If the constructor requires more than one argument, the initializer must take the form of a function call:



```
InventoryItem inventory[3] = { InventoryItem("Hammer", 6.95, 12),
                               InventoryItem("Wrench", 8.75, 20),
                               InventoryItem("Pliers", 3.75, 10) };
```

Arrays of Objects

- It **isn't necessary** to call the **same constructor** for each object in an array:



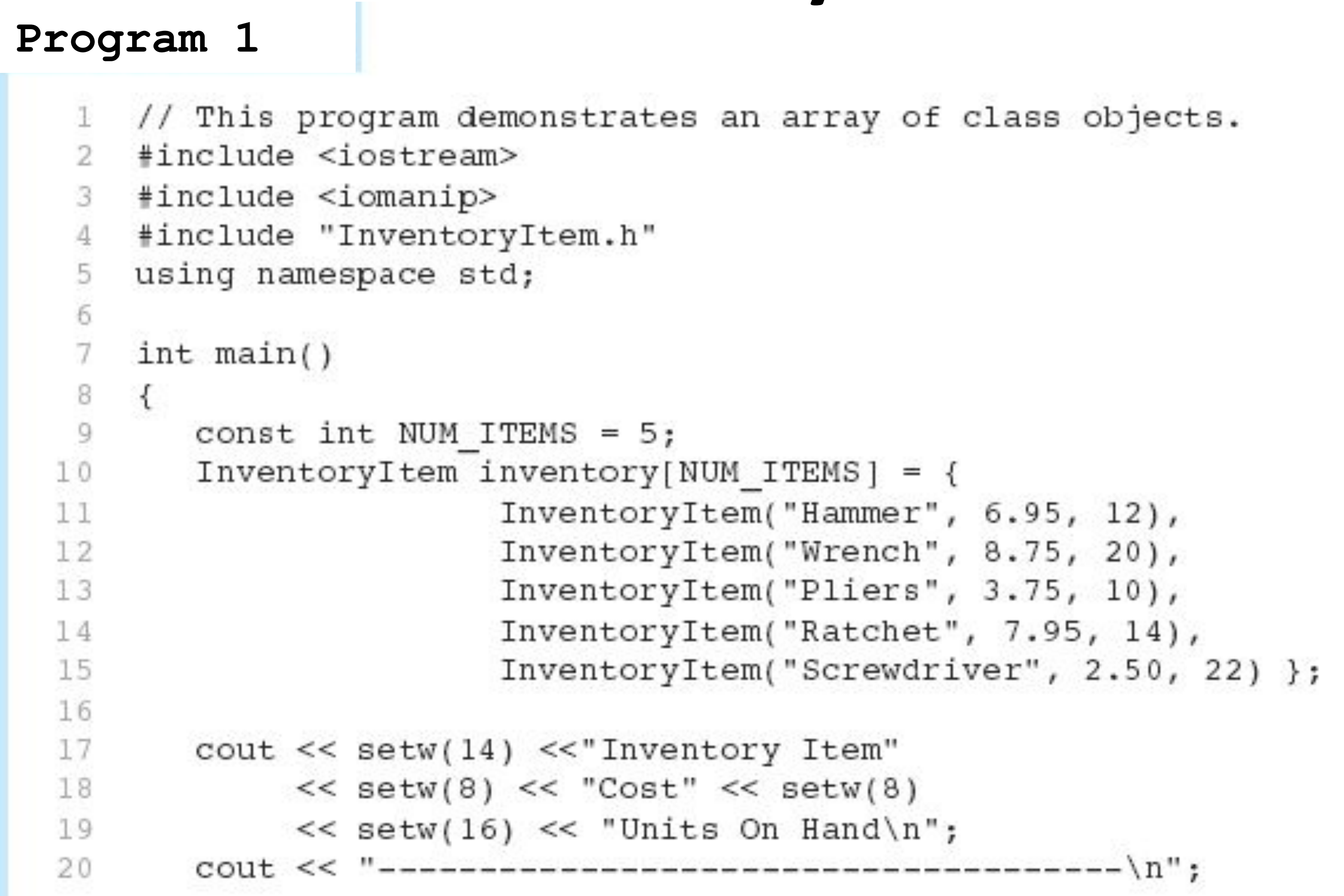
```
InventoryItem inventory[3] = { "Hammer",
                               InventoryItem("Wrench", 8.75, 20),
                               "Pliers" };
```

- **Objects in an array** are referenced using **subscripts**

- **Member functions** are referenced using **dot notation**:

```
 inventory[2].setUnits(30);
   cout << inventory[2].getUnits();
```

Example -Accessing Objects in an Array



Program 1

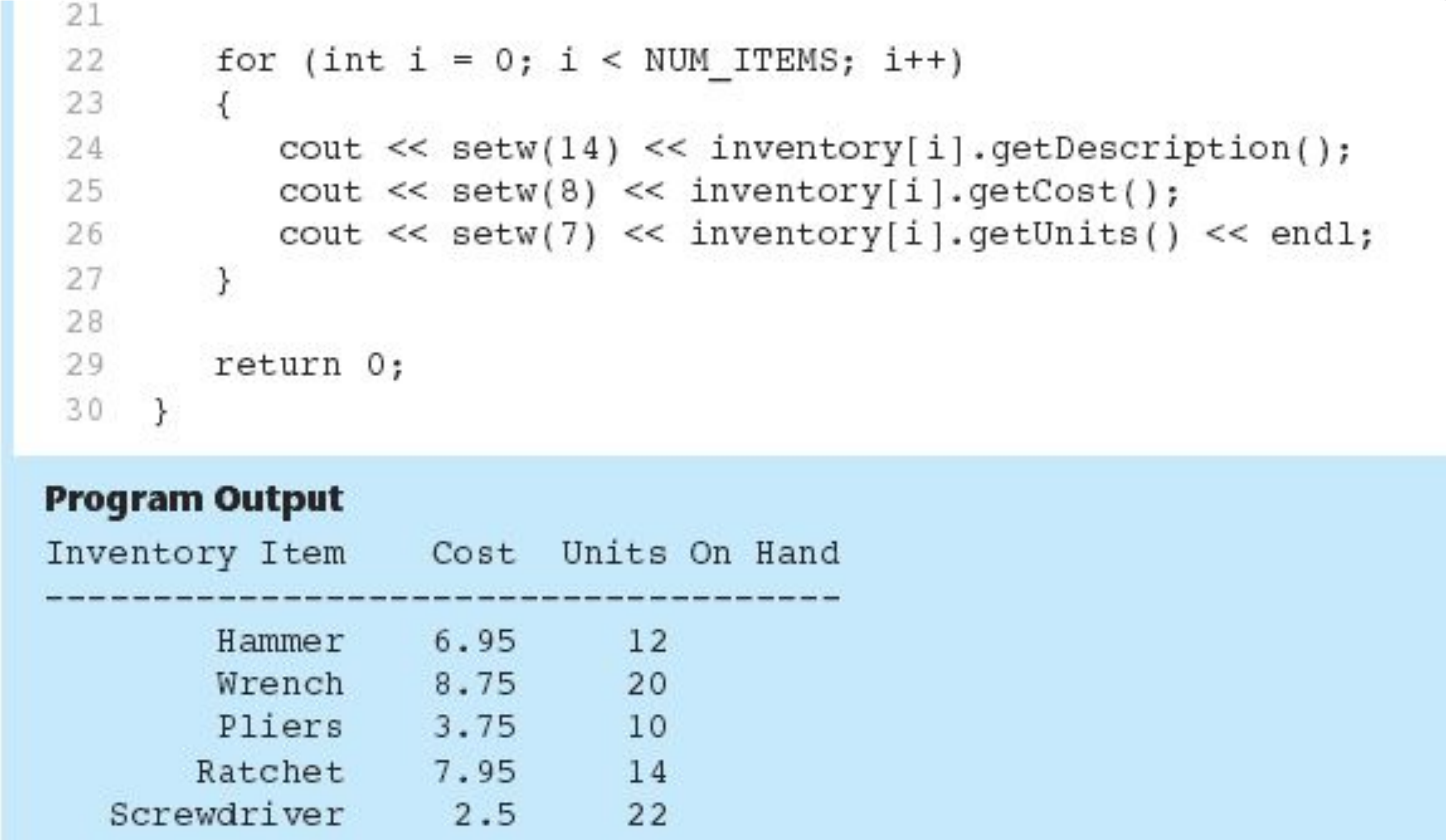
```
// This program demonstrates an array of class objects.
#include <iostream>
#include <iomanip>
#include "InventoryItem.h"
using namespace std;

int main()
{
   const int NUM_ITEMS = 5;
   InventoryItem inventory[NUM_ITEMS] = {
                  InventoryItem("Hammer", 6.95, 12),
                  InventoryItem("Wrench", 8.75, 20),
                  InventoryItem("Pliers", 3.75, 10),
                  InventoryItem("Ratchet", 7.95, 14),
                  InventoryItem("Screwdriver", 2.50, 22) };

   cout << setw(14) <<"Inventory Item"
        << setw(8) << "Cost" << setw(8)
        << setw(16) << "Units On Hand\n";
   cout << "-------------------------------------\n";
```

Example -Accessing Objects in an Array

Program 1 (continued)



```

    for (int i = 0; i < NUM_ITEMS; i++)
    {
        cout << setw(14) << inventory[i].getDescription();
        cout << setw(8) << inventory[i].getCost();
        cout << setw(7) << inventory[i].getUnits() << endl;
    }

    return 0;
}
```

Program Output

```
Inventory Item    Cost  Units On Hand
-------------------------------------
        Hammer    6.95     12
        Wrench    8.75     20
        Pliers    3.75     10
       Ratchet    7.95     14
   Screwdriver     2.5     22
```

Objects and Functions

Objects as Function Parameters

Passing Objects to Functions

- Can pass an object to a function in 3 ways:
  - Pass-by-value
  - Pass-by-reference
  - Pass-by-reference via pointer

Example 1: Pass-By-Value

```
#include <iostream>
using namespace std;
class Circle
{     private: double radius;
      public:
             Circle(double r){radius=r;}
             double getRadius(){return radius;}
             double getArea(){return radius*radius*3.14;}
};
void printCircle(Circle a)
{     cout<<a.getRadius()<<" "<<a.getArea();}

int main()
{   Circle ab(5.5);
    printCircle(ab);
    return 0;
}
```

Example 2: Pass-By-Value

```
class Count
{ public: int num;
          Count(int c){num = c;}
          Count(){num=0;}
};
void increment(Count c)
{    c.num++;   }

int main()
{ Count myCount;
  for(int i=0;i<10;i++)
     increment(myCount);
  cout<<myCount.num;
  return 0;
}
```

Example 1: Pass-By-Reference

```
#include <iostream>
using namespace std;
class Circle
{     private: double radius;
      public:
             Circle(double r){radius=r;}
             double getRadius(){return radius;}
             double getArea()
             {return radius*radius*3.14;}
};
void printCircle(Circle &a)
{      cout<<a.getRadius()<<" "<<a.getArea();}
int main()
{   Circle ab(5.5);
    printCircle(ab);
    return 0;
}
```

Example 2: Pass-By-Reference

```
class Count
{ public: int num;
          Count(int c){num = c;}
          Count(){num=0;}
};
void increment(Count &c)
{    c.num++;   }

int main()
{ Count myCount;
  for(int i=0;i<10;i++)
          increment(myCount);
  cout<<myCount.num;
  return 0;
}
```

Pass-By-Reference via Pointer

```
#include <iostream>
using namespace std;
class Circle
{     private: double radius;
      public:
             Circle(double r){radius=r;}
             double getRadius(){return radius;}
             double getArea(){return radius*radius*3.14;}
};
void printCircle(Circle *a)
{     cout<<a->getRadius()<<" "<<a->getArea();}
int main()
{   Circle ab(5.5);
    printCircle(&ab);
    return 0;
}
```

Example 2: Pass-By-Reference via Pointer

```
class Count
{ public: int num;
          Count(int c){num = c;}
          Count(){num=0;}
};
void increment(Count *c)
{    c->num++;   }
int main()
{ Count myCount;
  for(int i=0;i<10;i++)
          increment(&myCount);
  cout<<myCount.num;
  return 0;
}
```

Returning Objects from Functions

Example

```
class ClassName {
private:  int x, y;
public:
   ClassName readData()
   {
    ClassName temp;
    cout << "please input x and y "<<endl;
    cin>>x;
    cin>>y;
    temp.x=x+2;
    temp.y=y*3;
    return temp;
    }

    void display(){ cout << " x: " << x << endl << " y "
   << y <<endl;    }
};
```

Example (continue)

```
int main()
{
   ClassName o1, o2;
   o2 = o1.readData();
   o1.display();
   o2.display();

   return 0;
}
```

Operator Overloading

Operator Overloading

- Operators such as =, +, and others can be **redefined** when used with objects of a class

- The name of the function for the overloaded operator is `operator` followed by the operator symbol, *e.g.*,

  `operator+` to overload the + operator, and

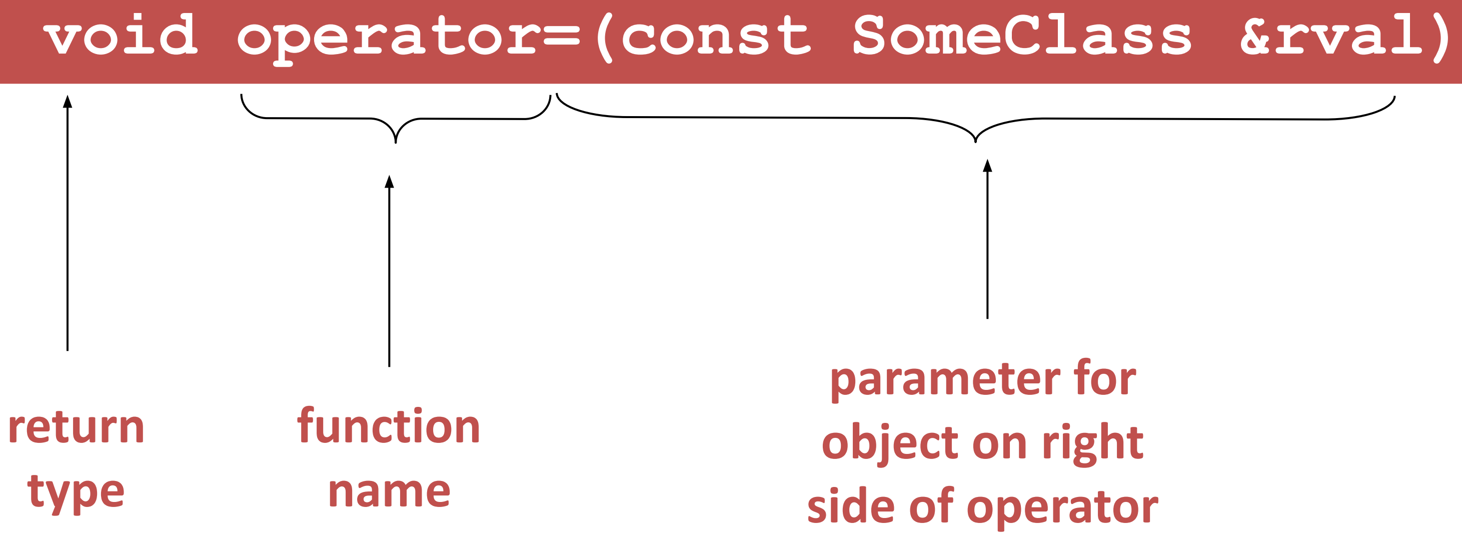
  `operator=` to overload the = operator

- Prototype for the overloaded operator goes in the declaration of the class that is overloading it

- Overloaded operator function definition goes with other member functions

Operator Overloading

- Operators such as =, +, and others can be redefined when used with objects of a class. Prototype:



```
void operator=(const SomeClass &rval)
```

return type

function name

parameter for object on right side of operator

- Operator is called via **object on left side**

Invoking an Overloaded Operator

- Operator can be invoked as a member function:

```
object1.operator=(object2);
```

- It can also be used in more conventional manner:

```
object1 = object2;
```

Example: operator=

```
class PersonInfo
{
private:
   char *name;   int age;
public:
      PersonInfo(char *n, int a) // Constructor
      { name = new char[strlen(n) + 1];
        strcpy(name, n);     age = a; }

   // Copy Constructor
   PersonInfo(const PersonInfo &obj)
      { name = new char[strlen(obj.name) + 1];
        strcpy(name, obj.name);
        age = obj.age; }

    ~PersonInfo() // Destructor
      { delete [] name; }
```

```
// Accessor functions
   const char *getName()
      { return name; }

   int getAge()
      { return age; }

   // Overloaded = operator
   void operator=(const PersonInfo
      &right)
      { delete [] name;
        name = new
      char[strlen(right.name) + 1];
        strcpy(name, right.name);
        age = right.age; } };
```

```
PersonInfo person1("Molly McBride", 27);
PersonInfo person2 = person1;
```

Returning a Value

- Overloaded operator can **return a value**

```
class Point2d
{
  public:
    double operator-(const point2d &right)
    { return sqrt(pow((x-right.x),2)
          + pow((y-right.y),2)); }
...
  private:
    int x, y;
};
Point2d point1(2,2), point2(4,4);
// Compute & display distance between 2 points
cout << point2 - point1 << endl;
// displays 2.82843
```

Returning a Value

- Return type the same as the left operand supports notation like:

```
object1 = object2 = object3;
```

- Function declared as follows:

```
const SomeClass operator=(const someClass &rval)
```

- In function, include as last statement:

```
return *this;
```

Example

```
// Overloaded = operator
const PersonInfo PersonInfo::operator=(const PersonInfo
    &right)
{
    delete [] name;
      name = new char[strlen(right.name) + 1];
      strcpy(name, right.name);
      age = right.age;
    return *this;
}
```

```
PersonInfo person1("Molly McBride", 27);
PersonInfo person2, person3;
person3=person2=person1;
```

The `this` Pointer

- `this`: predefined pointer available to a class’s member functions
- **Always points to the instance (object)** of the class whose function is being called
- Can be used to access members that may be hidden by parameters with same name
- Is passed as a hidden argument to all **non-static member functions**

Example: this Pointer

```
class SomeClass
{
   private:
      int num;
   public:
      void setNum(int num)
      { this->num = num; }
      ...
};
```

Exercise

- Write definition of the 2 overloaded operator functions
- Write an appropriate main function to test the class.

```
class Rectangle {
   int height, width;
   public:
   Rectangle(int a=0,int b=0)
   {height=b; width=a;}
   int getWidth() { return width;}
   int getHeight() { return height;}
   friend Rectangle operator+(Rectangle,Rectangle);
   Rectangle operator-(Rectangle);
};
```

Notes on Overloaded Operators

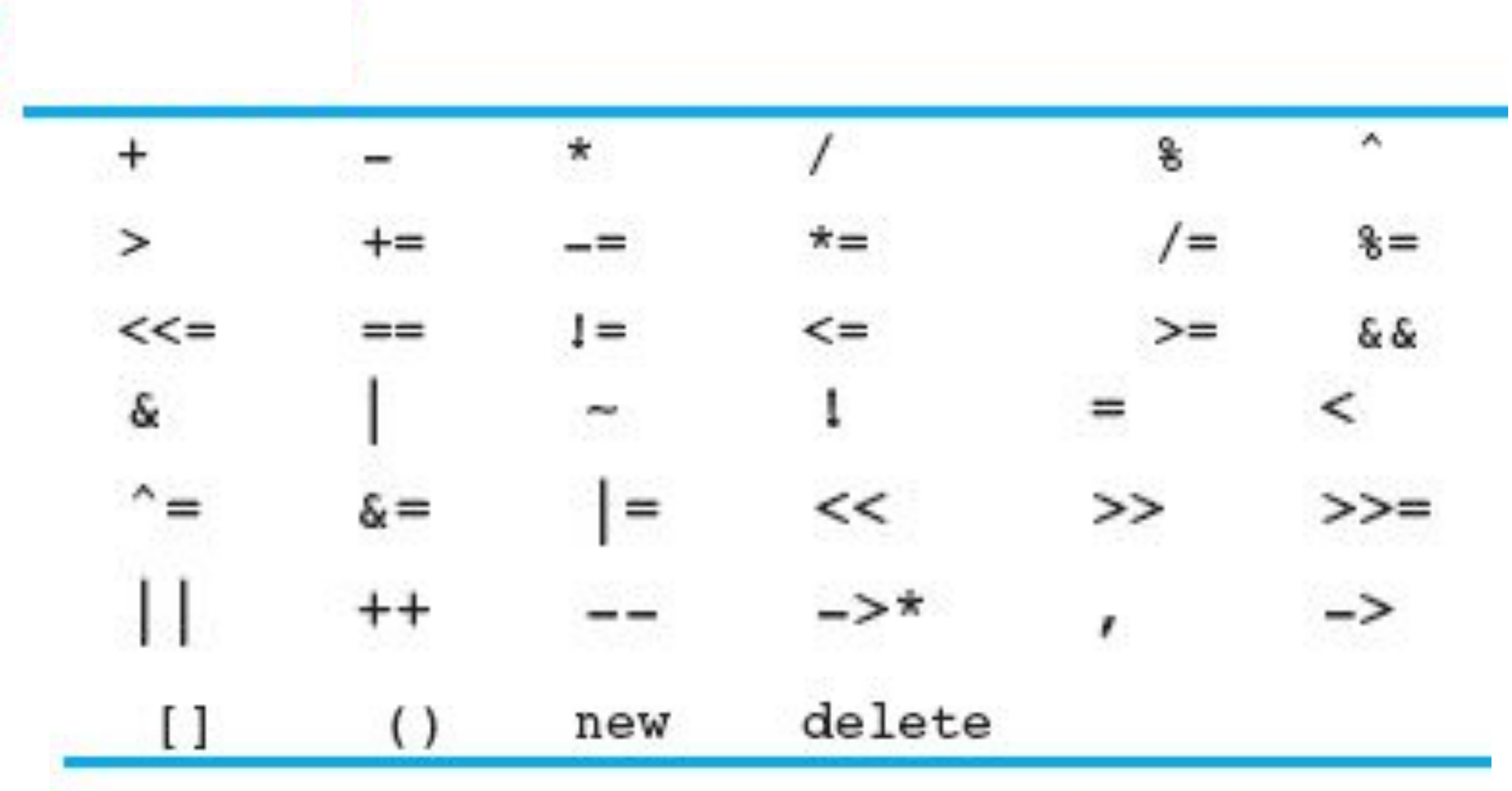
- Can change meaning of an operator

- Cannot change the number of operands of the operator

- Only certain operators can be overloaded. Cannot overload the following operators:

```
    ?:   .   .*   :: sizeof
```

C++ operators that may be overloaded



+	-	*	/	%	^
>	+=	-=	*=	/=	%=
<<=	==	!=	<=	>=	&&
&	|	~	!	=	<
^=	&=	|=	<<	>>	>>=
||	++	--	->*	,	->
[]	()	new	delete		

Overloading Types of Operators

- ++, -- operators overloaded differently for prefix vs. postfix notation

- Overloaded relational operators should return a **`bool`** value

- Overloaded stream operators >>, << must **return reference to `istream`, `ostream` objects** and **take `istream`, `ostream` objects as parameters**

Example: Relational Operators

```
class FeetInches {
private:
  int feet; int inches;
  void simplify();
public:
    FeetInches(int f = 0, int i = 0);
    void setFeet(int f);
    void setInches(int i);
    int getFeet() const;
    int getInches() const;
    FeetInches operator + (const FeetInches &); // Overloaded +
    FeetInches operator - (const FeetInches &); // Overloaded -
    FeetInches operator ++ ();   // Prefix ++
    FeetInches operator ++ (int);  // Postfix ++
    bool operator > (const FeetInches &);     // Overloaded >
    bool operator < (const FeetInches &);     // Overloaded <
    bool operator == (const FeetInches &);   // Overloaded ==
   friend ostream &operator << (ostream &, const FeetInches &);
   friend istream &operator >> (istream &, FeetInches &);
};
```

Example: Prefix and Postfix

```
//Overloading prefix ++
FeetInches FeetInches::operator ++ ()
{
      ++inches;
      simplify();
      return *this;
}
//Overloading postfix ++
FeetInches FeetInches::operator ++ (int)
{
      FeetInches temp(feet, inches);
      inches++;
      simplify();
      return temp;
}
```

```
FeetInches first, second(1,5);

first=++second;
first=second++;
```

Dummy parameter

Copy to store data before increment

Example: Relational Operator

```
bool FeetInches::operator > (const FeetInches &right){
    bool status;
    if (feet > right.feet)
      status = true;
    else if (feet == right.feet && inches > right.inches)
      status = true;
    else
      status = false;
    return status;
}
```

```
FeetInches first, second;
//setting first & second here
 if (first > second)
     cout << "first is greater than second.\n";
```

Example: >> and <<

```
ostream &operator<<(ostream &strm, const FeetInches &obj){
   strm << obj.feet << " feet, " << obj.inches << " inches";
   return strm;
}
istream &operator >> (istream &strm, FeetInches &obj)
{   // Prompt the user for the feet.
       cout << "Feet: ";   strm >> obj.feet;
   // Prompt the user for the inches.
      cout << "Inches: ";   strm >> obj.inches;
   // Normalize the values.
      obj.simplify();
   return strm;
}
```

```
FeetInches first;
//setting first feet=6 Inches=5
cin>>first;
cout << first;
```

Overloaded [ ] Operator

- Can create classes that behave like arrays, provide **bounds-checking** on subscripts

- Must consider constructor, destructor

- Overloaded [ ] returns a reference to object, not an object itself

Object Conversion

Object Conversion

- Can change meaning of an operator. Type of an object can be converted to another type
- Automatically done for built-in data types
- Must write an operator function to perform conversion
- To **convert an `FeetInches`** object to an **`int`**:

```
    FeetInches::operator int() {return feet;}
```

- Assuming distance is a `FeetInches` object, allows statements like:

```
    FeetInches distance;
    int d = distance;
```