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C++ for C Programmers

by JT Kalnay

¹**This book is dedicated to Dennis Ritchie and to Steve**
²**Jobs.**

³

⁴**To Dennis for giving us the tools to program.**

⁵

⁶**To Steve for giving us a reason to program.**

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1About This Book

2

3This book is not organized in a traditional chapter format.

4Instead I have chosen to include example programs that illustrate the important

5points of C++ in an evolutionary manner. Where appropriate, I have provided C code that would

6accomplish the same things that the C++ code would do to illustrate the specific advantage

7of C++. This comparison is useful as both a teaching tool and a motivational tool.

8

9The programs that I present are not, by themselves, complete applications. The programs are “single-issue
10teaching programs”. Experienced programmers who are learning a new language have told me time and

11time again that they mainly want to see the functionality of the new syntactic and semantic elements. The

12programmers tell me that they will be able to think of the applicability of the feature to their project. When

13necessary, I provide a sample application to give a feel for how the new element might be employed.

14

15The programs are presented in an order that presents the simplest, most straightforward aspect of a new

16element first. Subsequent programs present the more subtle or confusing aspects of a new element. This is

17a proven pedagogical approach for teaching C++ that I have presented to over 1,000 professionals and

18college students.

19

20This book assumes that you are already a GOOD C programmer and are able to learn well on your own.

21Simple (and peripheral) C++ concepts such as the cout/cin i/o mechanisms and how they replace

22printf/scanf ... are left to the end or for the reader. To ease the learning curve, and to focus on the

23compelling differences between C and C++, many C functions are used in place of the identical

24corresponding C++ rewrites.

25

26Good luck in your study of C++.

1	
2	Prologue
3	What C++ is.
4	Why C programmers should learn C++.
5	
6	Non Class Issues
7	Variable Definitions
8	Scope of Variables
9	Visibility of Variables
10	Function Prototype Headers
11	Polymorphic Functions
12	Default Arguments for Functions
13	References
14	
15	Data Hiding
16	Private Data
17	Member Functions
18	
19	The Evolution From <u>struct</u> To <u>class</u>
20	Constructors
21	Get/Set Functions (Error Checking)
22	Overloading Member Functions on Argument List
23	Overloading Relational Operators
24	Overloading Arithmetic Operators
25	Overloading I/O Operators
26	
27	Inheritance
28	Public, Private
29	Virtual Functions
30	Polymorphic Data Structures
31	
32	Memory Allocation
33	
34	C++ I/O

What is C++?

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2

3C++, at its essential core, is C with additional syntax to implement objects through the mechanism of
4classes. C++ upgrades the struct keyword with several new features;

5 data hiding

6 encapsulation

7 polymorphism.

8

9The extensions to the struct keyword are significant enough that the keyword "class" has been added
10to the language to replace and/or augment "struct". A class in C++ is the mechanism which facilitates the
11writing of Object Oriented programs.

12

13Why you should learn C++.

14

151) Data hiding and Functional Implementation hiding via private data and public interface coding.

16

17 Skilled C programmers utilize techniques to implement data hiding. C++ formalizes and thus
18 facilitates this practice.

19

202) Being able to define operators for your data structures without having to introduce new names
21 into the programmers vocabulary.

22

23 In C, you define data structures with the struct keyword. The only operation defined for structs
24 is =, a memberwise copy. If you want to add two instances of a struct, or compare two instances
25 of a struct, you have to write a subroutine to perform the function and you have to advertise the
26 name of the subroutine to the programmer that will be using it. This is silly. You already have
27 the + and == operators to add and test for equivalency. Why can't you use them for user defined
28 types? In C++, you can define the data structure and what any of the standard operators
29 (+ ++ - - == * / ...) mean with respect to that data structure. Having operators for your data
30 structures simplifies the programmer's job. They don't have to learn as many subroutine names
31 to be able to use your data structure.

32

333) User defined variable initialization and deallocation code.

34

35 In C, when someone declares an instance of one of your data structures, the system executes
36 code that is responsible for assigning initial values to that data structure. The user may specify
37 initial values, however it is still system code that runs.

38 In C++, you have the option of writing what is known as constructor code. When someone
39 declares an instance of one of your data structures, your constructor code can be executed. This
40 can be extremely useful for error checking, data validation, user validation, auditing, billing, and
41 tracking reasons.

42

434) Anything you can do in C you can do in C++.

44 Not everything you can do in C++ can be done in C.

45

465) Many new commercially available code libraries will only work with C++.

47

Section 2

1	
2	
3	This section covers the parts of C++ that are building blocks for classes. These topics can be studied before
4	or after learning about classes. However, to be able to fully exploit the power of classes, an understanding
5	of these topics is very valuable.
6	
7	ch1p1.cpp C++ commenting mechanisms
8	C++ and the if then else of C
9	C++ and the for, while, do of C
10	C++ and the printf of C and the cout of C++
11	
12	vardefs.cpp C++ and the int, float, char of C
13	C++ and the new possible locations of variable declarations
14	
15	scope.cpp C++ and the scope of variables
16	The C++ Scope Resolution Operator (sro) ::
17	
18	scope1.cpp The sro extended to include subroutine code
19	
20	protos.c C and its traditional weak function prototype header checking
21	
22	protos.cpp C++ and tighter function prototype header checking
23	C++ needs tighter prototype checking because it allows for polymorphic functions.
24	Several functions may have the same name, as long as they have different argument
25	lists. The functions are distinguishable by their argument lists and thus the error
26	checking performed by the prototype header checking becomes very important.
27	
28	protos1.cpp A polymorphic function
29	
30	protos2.cpp Polymorphic functions taken to a ridiculous, yet pedagogically valuable extreme.
31	
32	reversi.cpp A programmer friendly usage for polymorphic functions.
33	
34	defaults.cpp C++ allows a function to have default arguments defined for the incoming argument list.
35	This way, if a function is called with less than the required number of arguments in the
36	calling list, the missing arguments can be filled in using the defaults.
37	
38	polydef.cpp There can be a side effect when using polymorphic functions and functions with default
39	argument lists. This program illustrates the potential pitfall.
40	
41	refs.cpp C++ and the reference feature. A reference is not a pointer. This program points that
42	out.
43	
44	refs1.cpp References in action.
45	
46	refs2.cpp Extremely clever thing you can do with references.

1// ch1p1.cpp

```
2// this program introduces C++ comments, variables, decisions and loops
3// the double slashes are an addition to C++
4// they are a commenting mechanism
5// a double slash comment can begin anywhere on a line and continues
6// until the end of that line and that line only
7
8/* the slash asterisk, asterisk slash comment method */
9/* is still
10    in use */
11
12#if 0
13    to comment out long passages
14    of code, the #if 0 and the #ifdef mechanisms
15    are still available
16#endif
17
18#include <stdio.h>           // get access to printf scanf
19#include <iostream.h>       // get access to cout and cin
20
21// main is still the program entry point and by default still returns an int
22main()
23{
24    // the { is still the start of scope operator
25    // the } is still the end of scope operator
26
27    int i = 5;               // int is still a keyword
28    float f = 7.2;          // float is still a keyword
29    char x = 'a';           // char is still a keyword
30
31    // all the decision structures are the same as in C, if, switch, goto
32    if ( i < 7 ) // the relational operators are the same, < <= > >= != ==
33    {
34        printf("i was less than 7\n"); // if is identical
35        printf("i was %i\n",i);        // printf is identical, although often replaced with cout
36    }
37    else
38    {
39        cout << "i was greater than or equal to 7\n"; // cout is new
40        cout << "i was " << i << endl; // it can replace printf
41    }
42
43    // all the looping structures are the same as in C for, while, do
44    for ( i = 10; i < 13; i++ )
45        printf("%i squared is %i \n",i, i*i);
46
47}
48
```

1// vardefs.cpp

```
2// This program illustrates that C++ can declare variables the same as C.
3// It also illustrates that in C++ you may declare variables anywhere you want.
4// This is an extension to variable declaration in C.
5// A common C++ programmer trick is illustrated, along with its side-effect.
6// The C programmer who is used to declaring all their variables at the
7// beginning of a program may continue to do so, however, there are
8// advantages to waiting to declare a variable until it is needed, especially
9// in programs that will run for hours or days
10#include <stdio.h>
11main()
12{
13    int i;                // declare i, don't initialize it
14    int j = 5;            // declare and initialize j
15    printf("i is %i j is %i \n",i,j); // show i and j
16
17    int k = 7;            // declare another variable after first executable
18    printf("k is %i \n",k);
19
20    for ( i = 0; i < 3; i++ )    // i already exists
21    {
22        int i = 0;            // in a new scope, a new i is created
23        printf("INSIDE LOOP i is %i\n",i); // this is the inside i
24    }                          // the inside i goes out of scope and
25                                // is deallocated each time around loop
26    printf("After loop i is %i\n",i);
27
28    // we can create a new variable anywhere, l is local to main
29    // l is not local to the loop, the l declared inside the scope is local
30    // to the loop
31
32    for ( int l = 0; l < 3; l++ ) // l is created once, at start of loop
33    {
34        int l = 0;            // in a new scope, a new l is created
35        printf("inside loop l is %i \n",l); // this is the inside l
36    }                          // the inside l goes out of scope and
37                                // is deallocated each time around loop
38    printf("After loop l is %i\n",l);
39
40#ifdef BUG
41    // this would be a redefinition of l, remember l is local to main
42    // l is not local to the loop, many programmers confuse this issue
43    for ( int l = 0; l < 3; l++ ) // l is created once, at start of loop
44    {
45        int l = 0;            // in a new scope, a new l is created
46        printf("inside loop l is %i \n",l); // this is the inside l
47    }                          // the inside l goes out of scope and
48                                // is deallocated each time around loop
49    printf("After loop l is %i\n",l);
50#endif
51}
```

1Output From Running Program

2

3i is 0 j is 5

4k is 7

5

6INSIDE LOOP i is 0

7INSIDE LOOP i is 0

8INSIDE LOOP i is 0

9After loop i is 3

10

11

12inside loop l is 0

13inside loop l is 0

14inside loop l is 0

15After loop l is 3

16

17

18

19

20main()

21{

22int i;

23

24for (i = 0; ...

25{

26int i;

27

28}

29

30

31}

32

33

34

35

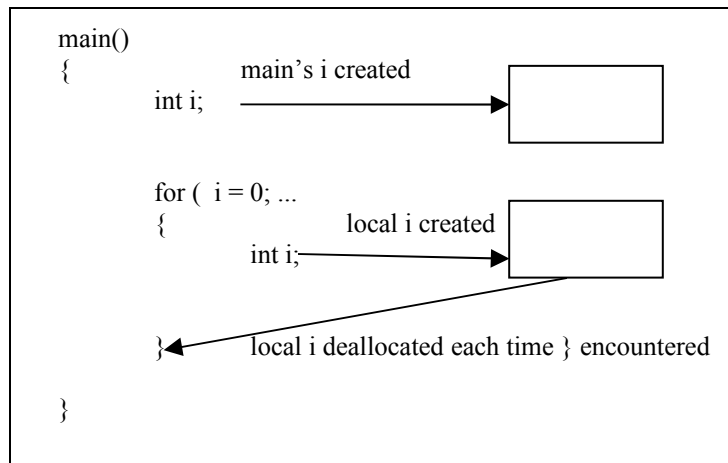
36

37C++ allows you to declare variables the same way you did in C.

38C++ also allows you to declare variables anywhere you want, even after executable statements.

Notice that each time around the loop, the internal I was re-created, and re-initialized to 0

Notice that each time around the loop, the internal l was created, and re-initialized to 0



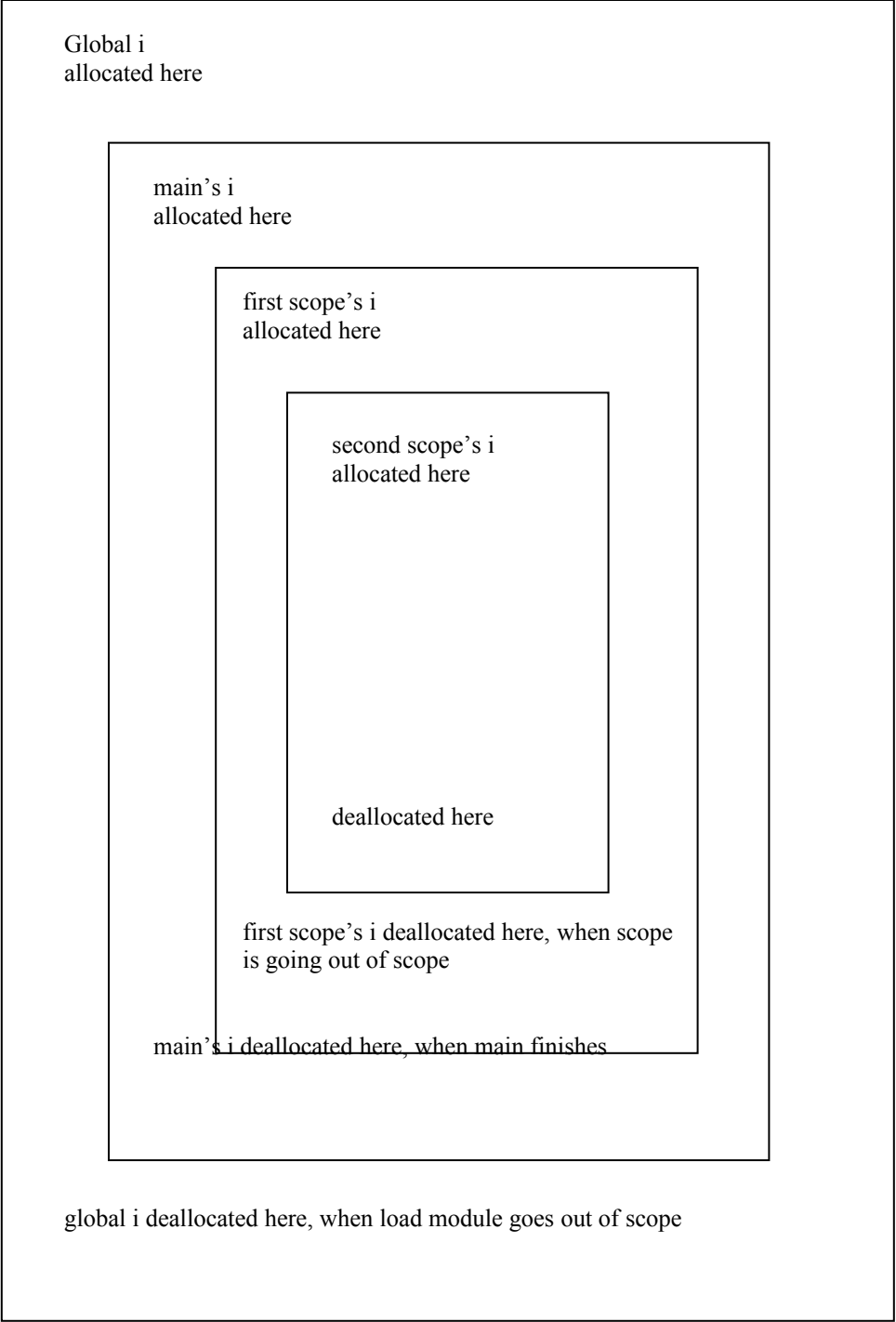
1// scope.cpp

```
2// C and C++ share variable scoping rules
3// C++ provides a new operator, the scope resolution operator ::
4// this operator can be used to distinguish between a local variable
5// and a global variable by the same name.
6#include <stdio.h>
7
8int i = 5;    // i is a global variable, we'll call it global i, we can access it anywhere via ::i
9int j = 7;    // j is also a global variable, we'll call it global j, we can access it anywhere via ::j
10main()
11{
12    int i = 50;    // i is a local variable, we'll call it main's i
13    printf("i is %i \n",i);    // the local variable will be printed
14    printf("::i is %i \n",::i);    // the global variable will be printed
15
16    printf("j is %i \n",j);    // the local variable will be printed
17    printf("::j is %i \n",::j);    // the global variable will be printed
18
19    // start a new scope
20    {
21        int i = 500;    // this i is local to the scope
22        printf("\n\tIN FIRST SCOPE\n");
23        printf("\ti is %i \n",i);    // local var printed
24        printf("\t::i is %i \n",::i);    // global var printed
25        printf("\tj is %i \n",j);    // local var printed
26        printf("\t::j is %i \n",::j);    // global var printed
27
28        // start another new scope
29        {
30            int i = 5000;    // local to scope
31            int j = 7000;    // local to scope
32            printf("\n\t\tIN INNERMOST SCOPE\n");
33            printf("\t\ti is %i \n",i);    // local printed
34            printf("\t\t::i is %i \n",::i);    // global printed
35            printf("\t\tj is %i \n",j);    // local printed
36            printf("\t\t::j is %i \n",::j);    // global printed
37        }
38        printf("\n\tAFTER INNERMOST SCOPE\n");
39        printf("\ti is %i \n",i);    // local var printed
40        printf("\t::i is %i \n",::i);    // global var printed
41        printf("\tj is %i \n",j);    // local var printed
42        printf("\t::j is %i \n",::j);    // global var printed
43    }
44    printf("\n\tAFTER FIRST SCOPE\n");
45    printf("i is %i \n",i);    // local var printed
46    printf("::i is %i \n",::i);    // global var printed
47    printf("j is %i \n",j);    // local var printed
48    printf("::j is %i \n",::j);    // global var printed
49}
```

1Output From Running Program

2		At this point in the program there is the global i and
3		there is main's i
4	i is 50	i all by itself refers to the i local to the scope
5	::i is 5	::i refers to the GLOBAL i
6	j is 7	
7	::j is 7	
8		
9	IN FIRST SCOPE	now there are three i's, therefore i and ::i are different
10	i is 500	i all by itself refers to the i local to the scope
11	::i is 5	::i refers to the GLOBAL i
12	j is 7	
13	::j is 7	
14		
15	IN INNERMOST SCOPE	now there are four i's, therefore i and ::i are different
16	i is 5000	i all by itself refers to the i local to that scope
17	::i is 5	::i refers to the GLOBAL i, not the i one scope out
18	j is 7000	
19	::j is 7	
20		
21	AFTER INNERMOST SCOPE	now we are back to just three i's
22	i is 500	i refers to the i local to that scope
23	::i is 5	::i refers to the GLOBAL i
24	j is 7	
25	::j is 7	
26		
27	AFTER FIRST SCOPE	
28	i is 50	
29	::i is 5	
30	j is 7	
31	::j is 7	
32		

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1// scope1.cpp

2// the scope resolution operator applies in subroutines as well

3// a subroutine may have a local instance of a variable and still reference a global variable with

4// the same name via the :: operator

```
5
6#include <stdio.h>
7#include <iostream.h>
8
9int i = 5;           // this is a global variable
10int j = 7;          // this is also a global variable
11
12void func1(void)
13{
14    // declare a local i
15    // do not declare a local j
16    int i = 25;
17    cout << "IN func1 i is " << i << endl;           // i, all by itself, refers to the local i
18    cout << "IN func1 ::i is " << ::i << endl;       // ::i refers to the GLOBAL i, not main's i
19
20    cout << "IN func1 j is " << j << endl;           // j, all by itself, refers to the global j in this case
21    cout << "IN func1 ::j is " << ::j << endl;       // because there is no local j
22    return;
23}
24
25main()
26{
27    int i = 50;           // this i is local to main, it is not visible to the subroutine
28    printf("i is %i \n",i); // the local variable will be printed
29    printf("::i is %i \n",::i); // the global variable will be printed
30
31    printf("j is %i \n",j); // the local variable will be printed
32    printf("::j is %i \n",::j); // the global variable will be printed
33
34    // call the function
35    func1();
36}
37
```

38Output From Running Program

```
39
40IN func1 i is 25           // the local i in the subroutine was accessed
41IN func1 ::i is 5         // the GLOBAL i, not main's i, was accessed via ::i
42IN func1 j is 7           // there was no local j, therefore the GLOBAL j was accessed
43IN func1 ::j is 7         // ::j also referred to the global j
44
45i is 50                   // the local i in main was accessed
46::i is 5                  // the GLOBAL i was accessed
47j is 7                    // the global j was accessed because there is no j local to main
48::j is 7                  // the global j was accessed
```



```

1// protos.c
2// C++ tightens the requirement for function prototype headers
3// In C, you can get away without having the header, sometimes with
4// disastrous results. In C++ you have to have the header.
5// This program could be compiled as a C program
6// This program could not be compiled as a C++ program because of missing prototype headers
7main()
8{
9    printf("IN main\n");
10   func1();
11}
12
13int func1(void)
14{
15   printf("IN Func1\n");
16   return 1;
17}
18
19Output From Running Program as a C Program
20IN main
21IN Func1
22
23Sample Output of Trying To Compile as a C++ Program
24CC protos.c
25"protos.c"      line 13: error:   undefined function func1 called
26Compilation failed

```

```

1// protos.cpp
2// C++ tightens the requirement for function prototype headers
3// In C, you can get away without having the header, sometimes with
4// disastrous results. In C++ you have to have the header.
5// This program could be compiled as a C++ program
6
7#include <stdio.h>           // these two lines are required to compile this
8int func1(void);           // program as a C++ program
9                           // without them you would get errors on the use of
10                          // printf and on the use of func1
11                          // C++ REQUIRES the function prototype headers
12
13main()
14{
15    printf("IN main\n");
16    func1();
17}
18
19int func1(void)
20{
21    printf("IN Func1\n");
22    return 1;
23}
24
25
26Output From Running Program
27IN main
28IN Func1

```

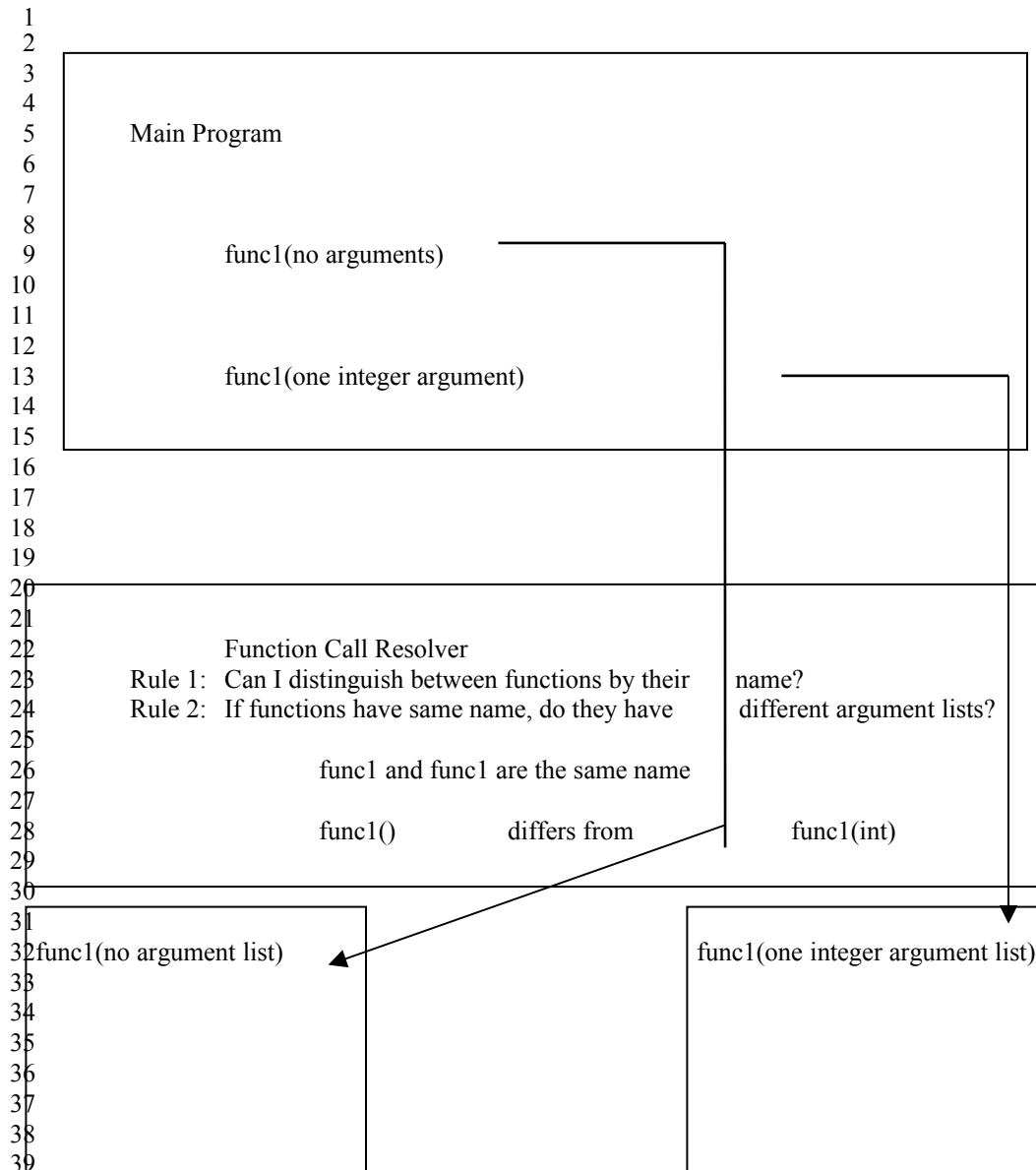
```

1// protos1.cpp
2// C++ tightens the requirement for function prototype headers
3// The reason it tightens the function prototype header rules
4// is related to the feature called polymorphism that C++ provides
5// examine the TWO FUNCTIONS func1
6// they have the same name, but take different argument lists
7// we will examine this closer in later programs
8
9#include <stdio.h>    // these two lines are required to compile this
10int func1(void);
11int func1(int);
12
13main()
14{
15    int i = 0;
16
17    printf("IN main\n");
18    printf("Before call i is %i\n\n",i);
19    i = func1();
20    printf("After first call i is %i\n\n",i);
21    i = func1(i);
22    printf("After second call i is %i\n\n",i);
23}
24
25
26function name:    func1
27return type:      int
28argument list:    void
29int func1(void)
30{
31    printf("IN func1, no argument version \n");
32    return 1;
33}
34
35function name:    func1
36return type:      int
37argument list:    int
38int func1(int)
39{
40    printf("IN func1, integer argument version \n");
41    return 253;
42}
43
44Output From Running Program
45
46IN main
47Before call i is 0
48
49IN func1, no argument version
50After first call i is 1
51
52IN func1, integer argument version
53After second call i is 253

```

← function name is func1 called via func1()

← function name is func1 called via func1(int)



1// **protos2.cpp**

2// a function may have the same name as another function as long as it differs in the argument list

3// this program takes this to the extreme

4

5#include <stdio.h> // these two lines are required to compile this

6#include <iostream.h>

7

8int func1(void); // prototype header for func1 with no argument list

9int func1(int); // prototype header for func1 with one integer in argument list

10int func1(float); // prototype header for func1 with one float in argument list

11int func1(int,int); // prototype header for func1 with two ints in argument list

12int func1(int,int,int); // prototype header for func1 with three ints in argument list

13int func1(int,int,int,int); // prototype header for func1 with four ints in argument list

14

15

16main()

17{

18 int i = 0;

19 float f = 1.1;

20

21 printf("IN main\n");

22 printf("Before call i is %i\n\n",i);

23 i = func1();

24 printf("After no arg call i is %i\n\n",i);

25

26 i = func1(i);

27 printf("After one int call i is %i\n\n",i);

28

29 i = func1(f);

30 printf("After float call i is %i\n\n",i);

31

32 i = func1(i,i);

33 printf("After two int call i is %i\n\n",i);

34

35 i = func1(i,i,i);

36 printf("After three int call i is %i\n\n",i);

37

38 i = func1(i,i,i,i);

39 printf("After four int call i is %i\n\n",i);

40}

```

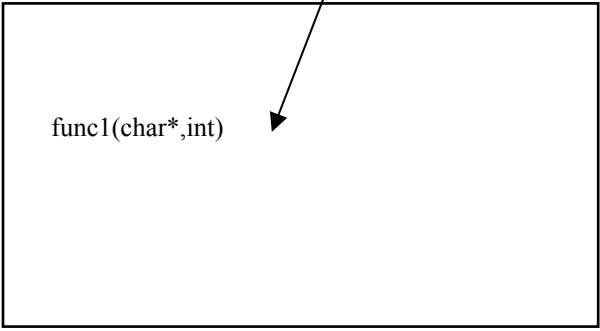
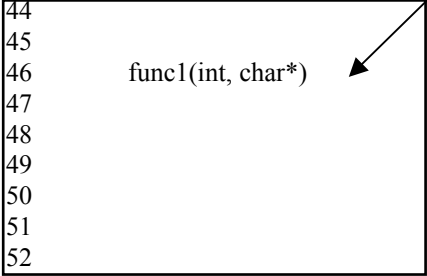
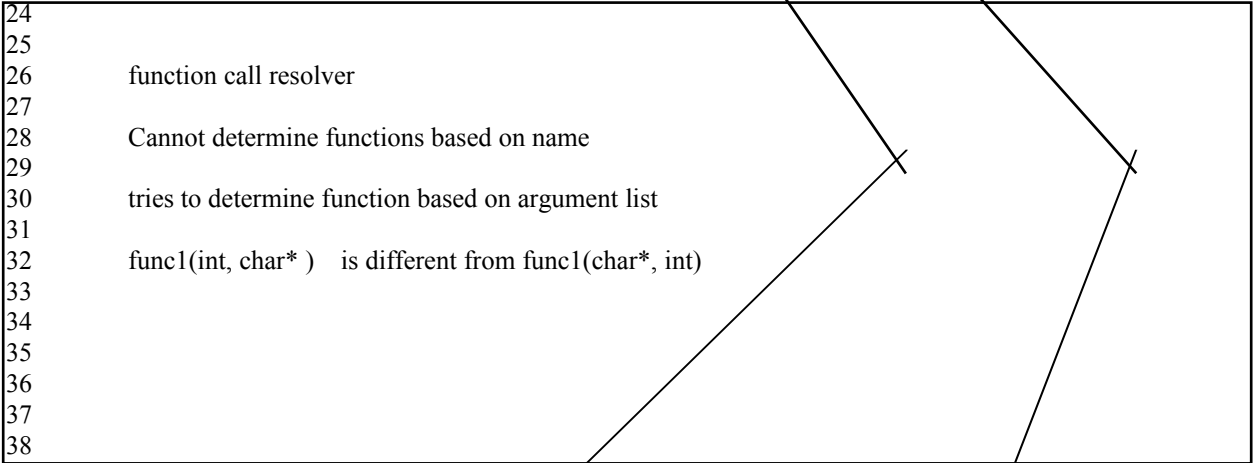
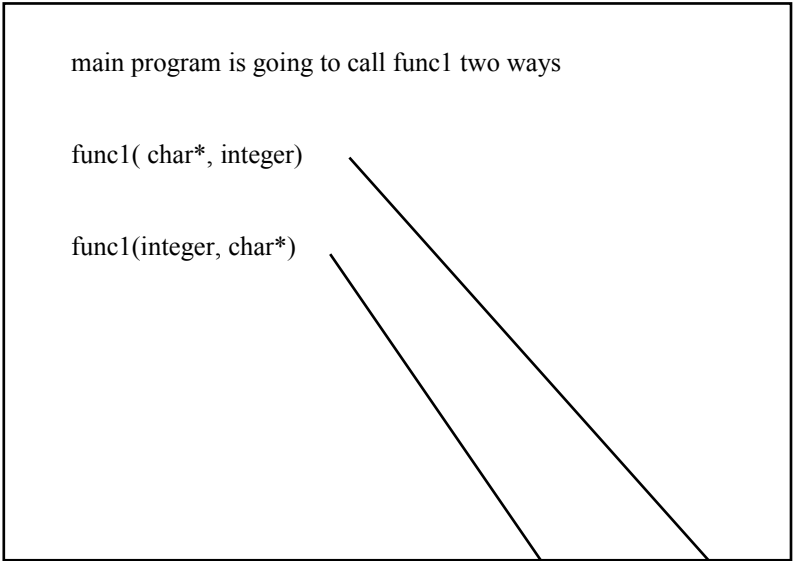
1// The ridiculous list of functions all with the same name
2// Having one function with one name is good, having two functions with the same name is okay
3// Having three functions with the same name is acceptable, but FOUR functions or more with the same
4// name? Are they really all doing the same thing? Maybe you need a different function name. Maybe not
5
6int func1(void) {
7    printf("IN func1, no argument version \n");
8    return 1; }
9
10int func1(int) {
11    printf("IN func1, integer argument version \n");
12    return 2; }
13
14int func1(float) {
15    printf("IN func1, float argument version \n");
16    return 3; }
17
18int func1(int,int) {
19    printf("IN func1, two integer argument version \n");
20    return 4; }
21
22int func1(int,int,int) {
23    printf("IN func1, three integer argument version \n");
24    return 5; }
25
26int func1(int,int,int,int) {
27    cout << "In func1, four integer argument version " << endl;
28    return 6; }
29
30Output From Running Program
31
32In func1, four integer argument version
33IN main
34Before call i is 0
35
36IN func1, no argument version
37After no arg call i is 1
38
39IN func1, integer argument version
40After one int call i is 2
41
42IN func1, float argument version
43After float call i is 3
44
45IN func1, two integer argument version
46After two int call i is 4
47
48IN func1, three integer argument version
49After three int call i is 5
50After four int call i is 6
51
52The function call resolver can tell all these functions apart by their argument lists

```

1// reversi.cpp

```
2// this program shows a handy feature of C++ polymorphic functions
3// When you have a function that takes two arguments of two different
4// types and a lot of people are going to use that function
5// you can make the function easier to use by allowing the programmer
6// to call the function with the arguments in either order
7
8// For example, if you have a function that requires an age and a name
9// you could allow the function to be called with the name first and age
10// second or the age first and the name second.
11
12void func1(char *, int);           // function prototype header for name first, age second
13void func1(int, char* );          // function prototype header for age first, name second
14
15#include <iostream.h>
16main()
17{
18    // call the function the first way
19    func1("bill", 32);
20
21    // call the function the second way
22    func1(89,"frank");
23
24}
25
26function name:   func1
27return type:     void
28argument list:   pointer to character, integer
29void func1(char * ptr, int age)
30{
31    cout << ptr << " is " << age << " years old " << endl;
32}
33
34function name:   func1
35return type:     void
36argument list:   integer, pointer to character
37void func1(int age, char * ptr)
38{
39    cout << ptr << " is " << age << " years old " << endl;
40}
41
42
43// MAINTENANCE POINT
44// you have to decide whether to use polymorphic names for a function or
45// whether to use default arguments for a function
46// you create a chicken and egg problem if you use both polymorphic names
47// for a function and default arguments for a function, see the next program
48
49Output From Running Program
50bill is 32 years old
51frank is 89 years old
```

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1// defaults.cpp

```
2// C++ allows you to write functions that have default arguments.
3// This is handy when you want to call a function that needs four
4// arguments but two or three of them are almost always the same.
5// Any arguments that you do supply to a function with default arguments
6// will fill in the argument list fields from left to right.
7// Imagine a function that requires the date passed in, with default
8// arguments, the function could assume that we are in the 20th century unless
9// told otherwise.

10
11// what you do is specify what the arguments are supposed to be if no value is provided.
12
13void func1(int = 1);           // if called with no args, arg set to 1
14void func2(int, int = 2);      // if called with no args, error
15                               // if called with one arg, second arg set to 2
16
17void func3(int, int, int = 27); // if called with no args, error
18                               // if called with one arg, error
19                               // if called with two args, third arg set to 27
20
21void func4(int = 1, int = 2, int = 3, int = 4); // if called with no args,
22                                               // first arg set to 1, second arg set to 2
23                                               // third arg set to 3, fourth arg set to 4
24#include <iostream.h>
25main()
26{
27    int i = 100, j = 200, k = 300, l = 400;
28
29    // what will be printed by each of these calls??
30    func1();
31    func1(i);
32    func1(j);
33    cout << endl;
34
35    // func2(); THIS WOULD BE A COMPILER ERROR. Can you answer why?
36    func2(i);
37    func2(i,j);
38    cout << endl;
39
40    // BOTH OF THESE WOULD BE COMPILER ERRORS. Can you answer why?
41    // func3();
42    // func3(i);
43    func3(i,j);
44    func3(i,j,k);
45    cout << endl;
46
47    func4();
48    func4(i);
49    func4(i,j);
50    func4(i,j,k);
51    func4(i,j,k,l);
52    cout << endl;
53}
```

```

1 void func1( int a )
2 { cout << "a is " << a << endl; }
3
4 void func2( int a, int b )
5 { cout << "a is " << a << " b is " << b << endl; }
6
7 void func3( int a, int b, int c )
8 { cout << "a is " << a << " b is " << b << " c is " << c << endl; }
9
10 void func4( int a, int b, int c, int d )
11 { cout << "a is " << a << " b is " << b << " c is " << c << " d is " << d << endl; }
12

```

13 In the program remember that these variables had these values

14 i = 100

15 j = 200

16 k = 300

17 l = 40

18

19 Output From Running Program

20

21 **Output Produced**

22 a is 1

23 a is 100

24 a is 200

25

26 a is 100 b is 2

27 a is 100 b is 200

28

29 a is 100 b is 200 c is 27

30 a is 100 b is 200 c is 300

31

32 a is 1 b is 2 c is 3 d is 4

33 a is 100 b is 2 c is 3 d is 4

34 a is 100 b is 200 c is 3 d is 4

35 a is 100 b is 200 c is 300 d is 4

36 a is 100 b is 200 c is 300 d is 400

Function Call That Was Made

func1()

func1(i)

func1(j)

func2(i)

func2(i,j)

func3(i,j)

func3(i,j,k)

func4()

func4(i)

func4(i,j)

func4(i,j,k)

func4(i,j,k,l)

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main calls func1, can call it with one int or with not ints

main calls func2, can call it with one int or two ints
cannot call it with no ints

main calls func3 with two ints or three ints
cannot call it with no or one ints

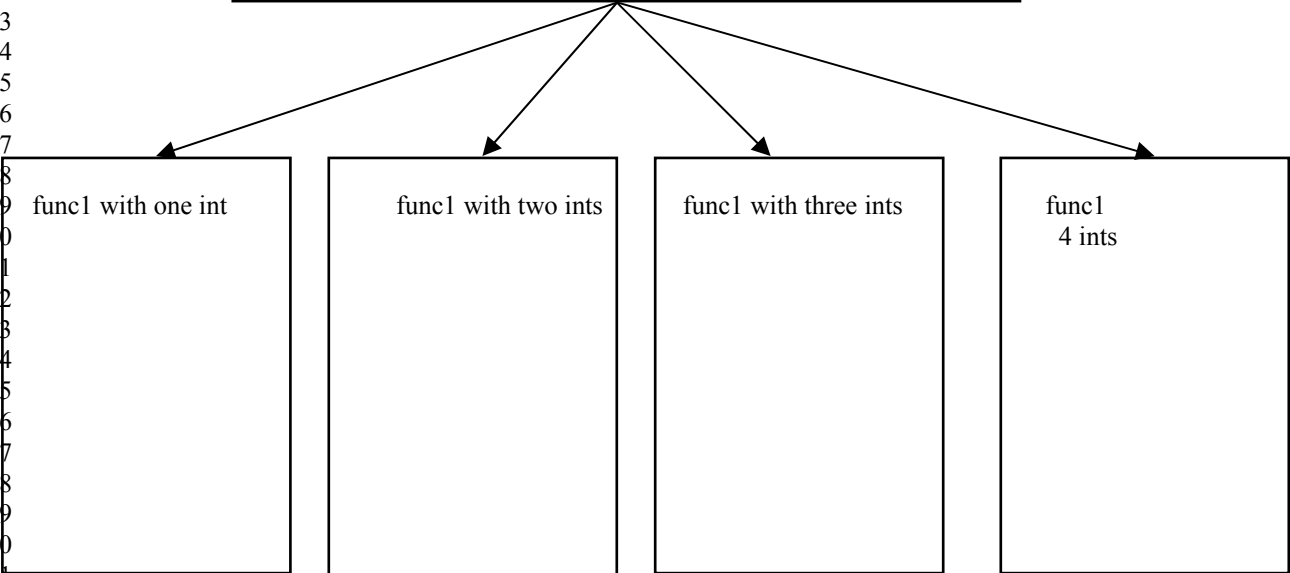
main calls func4 with zero, one, two three or four ints

Function Call Resolver

Can tell functions apart by their names

But what does it do when it gets called with func1 and no ints?
it fills in the one default and calls func1 with one int!

What does it do when it gets called with func4 and two ints?
it fills in two more ints and calls func4 with four ints!



```

1// polydef.cpp
2
3// this program illustrates a potential problem using polymorphic names
4// for a function where you also supply default arguments for a function
5
6void func1(int, float = 2.34 );      // this could be called sending one int
7void func1(int);                    // this could also be called sending one int
8                                    // There would be no way for the function call resolver to figure
9                                    // out which one had been called
10
11#include <iostream.h>
12main()
13{
14    int i = 5;
15    float f = 9.99;
16
17    // call func1 sending one int, which gets called, the
18    // func1 with a single int arg or the func1 with an int
19    // and float default?
20    func1(i);
21
22    // call func1 sending an int and a float
23    func1(i,f);
24
25}
26
27function name:   func1
28return type:     void
29argument list:   one integer, no defaults
30void func1(int a)
31{
32    cout << "In one int arg func1 a = " << a << endl;
33}
34
35function name:   func1
36return type:     void
37argument list:   one integer and one float  OR
38                 one integer, with float added in as default by function call resolver
39void func1(int a, float b)
40{
41    cout << "In two arg func1 with float default " << endl;
42    cout << "int a is " << a << " float b is " << b << endl;
43}
44
45
46Output From Trying To Compile This Program
47
48CC polydef.cpp
49"polydef.cpp", line 18: error: two exact matches for func1(); void(int) and void(int,float)
50Ambiguous Function Call
51Compilation Failed

```

1// refs.cpp

```
2// C++ introduces the concept of a reference
3// A reference IS NOT a pointer, it has no memory of its own
4// A pointer is a pointer, it has memory of its own in which it
5// stores the address of the thing it is pointing at
6
7// In this program we introduce the basic syntax for declaring and using
8// a reference
9
10// Subsequent programs, especially refs2.cpp, show the use of a reference
11
12#include <iostream.h>
13
14main()
15{
16    int a = 1;           // a is an integer, it has its own memory
17    int &c = a;           // c is NOT an integer, it does not have memory
18                        // the syntax int & identifies c as a reference
19    int *ptr = &a;        // ptr is a pointer to an integer
20                        // it has the address of a stored in it
21
22    cout << "value of a is " << a << endl;
23    cout << "value of c is " << c << endl;
24    cout << "value of ptr is " << ptr << endl << endl;
25
26    cout << "address of a is " << &a << endl;
27    cout << "address of c is " << &c << endl;
28    cout << "address of ptr is " << &ptr << endl << endl;
29
30    a = 3;               // this changes the value of a
31    cout << "value of a is " << a << endl;
32    cout << "value of c is " << c << endl;
33    cout << "value of *ptr is " << *ptr << endl << endl;
34
35    c = 7;               // this also changes the value of a
36    cout << "value of a is " << a << endl;
37    cout << "value of c is " << c << endl;
38    cout << "value of *ptr is " << *ptr << endl << endl;
39
40    *ptr = -32;           // this also changes the value of a
41    cout << "value of a is " << a << endl;
42    cout << "value of c is " << c << endl;
43    cout << "value of *ptr is " << *ptr << endl << endl;
44}
```

```

1
2
3
4Output From Running Program
5value of a is 1
6value of c is 1
7value of ptr is 0x1833fff4
8
9address of a is 0x1833fff4
10address of c is 0x1833fff4
11address of ptr is 0x1833fff2
12
13value of a is 3
14value of c is 3
15value of *ptr is 3
16
17value of a is 7
18value of c is 7
19value of *ptr is 7
20
21value of a is -32
22value of c is -32
23value of *ptr is -32

```

Variable	Memory	Address
a c	1	0x1833fff4
ptr	0x1833fff4	0x1833fff2

1// refs1.cpp

2// This program shows the use of reference variables in calling a function
3// This notation will drive C programmers CRAZY because it seems to be
4// in direct conflict with how C does things. I agree. This is confusing

```
5
6#include <iostream.h>
7
8// a copy of the value of the calling argument is stored in x
9void call_by_value ( int x )
10{
11    cout << "call_by_value received " << x << endl;
12    cout << "address of x is " << &x << endl;
13    x++;
14    cout << "call_by_value generated " << x << endl;
15}
16
17// the name of the calling argument is stored in x
18// x will not be a local variable, x will BE the calling argument
19// x will not have to be dereferenced to access the contents
20void call_by_reference ( int& x )
21{
22    cout << "call_by_reference received " << x << endl;
23    cout << "address of x is " << &x << endl;
24    x++;
25    cout << "call_by_reference generated " << x << endl;
26}
27
28// the address of the calling argument is stored in x
29// x will be a local variable of type pointer to int
30// x will need to be dereferenced to access the contents
31void call_by_pointer ( int* x )
32{
33    cout << "call_by_pointer received " << x << endl;
34    cout << "call_by_pointer points at " << *x << endl;
35    cout << "address of x is " << &x << endl;
36    *x = *x + 1;
37    cout << "call_by_pointer generated " << *x << endl;
38}
```

```

1main()
2{
3    int i = 1;
4    cout << "ADDRESS OF MAIN i IS " << &i << endl;
5    cout << "i before call_by_value(i) " << i << endl;
6    call_by_value(i);           // only name of variable is used
7    cout << "i after call_by_value(i) " << i << endl << endl;
8
9    cout << "i before call_by_reference(i) " << i << endl;
10   call_by_reference(i);       // only name of variable is used
11   cout << "i after call_by_reference(i) " << i << endl << endl;
12
13   cout << "i before call_by_pointer(i) " << i << endl;
14   call_by_pointer(&i);        // need to generate address of variable
15   cout << "i after call_by_pointer(i) " << i << endl << endl;
16}

```

17
18Output From Running Program

	variable	memory	address
19			
20			
21ADDRESS OF MAIN i IS 0xd37fff4	main's i	1	0xd37fff4
22			
23			
24	call_by_value		
25i before call_by_value(i) 1			
26call_by_value received 1	local x	1	0xd37fff2
27address of x is 0xd37fff2			
28call_by_value generated 2			
29i after call_by_value(i) 1			
30			
31			
32			
33			
34			
35			
36i before call_by_reference(i) 1			
37call_by_reference received 1	call_by_reference		
38address of x is 0xd37fff4			
39call_by_reference generated 2	no local x	Main's i manipulated directly	
40i after call_by_reference(i) 2			
41			
42			
43			
44			
45			
46			
47i before call_by_pointer(i) 2	call_by_pointer		
48call_by_pointer received 0xd37fff4			
49call_by_pointer points at 2	ocal x	0xd37fff4	0xd37fff2
50address of x is 0xd37fff2	pointer to int		
51call_by_pointer generated 3			
52i after call_by_pointer(i) 3 manipulates main's i through *x			
53			

1// refs2.cpp

2// This program shows an EXTREMELY interesting way in which references can be utilized

3// It draws on the fact that a reference can appear on the LEFT of an

4// assignment statement or on the RIGHT of an assignment statement

5// Also, a reference can be the return value of a function

6

7#include <iostream.h>

8

9// this function receives references to two variables

10// It decides which one is largest and RETURNS THE REFERENCE

11int & largest(int& a, int& b)

12{

13 if (a > b)

14 return a;

15 else

16 return b;

17}

18

19main()

20{

21 int i = 10;

22 int j = 100;

23 int x = 0;

24

25 // this chunk shows how we EXPECT to use a function

26 cout << "x is " << x << endl;

27 x = largest(i,j);

28 cout << "x is " << x << endl << endl;

29

30 // by having the function return a reference, we can do this

31 // We are adding one to whichever of the two is larger

32 cout << "i is " << i << endl;

33 cout << "j is " << j << endl;

34 largest(i,j)++;

35 cout << "i is " << i << endl;

36 cout << "j is " << j << endl << endl;

37

38}

39Output From Running Program

40x is 0

41x is 100

42

43i is 10

44j is 100

45i is 10

46j is 101

47

48largest(i,j) resolves to either the variable i or j

49 it does not resolve to the value of i or j

50 it does not resolve to the address of i or j

51 it resolves to the variable i or j

52

53therefore largest(i,j)++ resolves to either i++ or j++

Section 3

1

2

3Class Mechanism

4Private Data

5Public Member Functions

6

7Programs use data structures. C provides the struct keyword for the specification of user defined data
8structures. Programs use subroutines to manipulate the data structures. If the data structures are only to be
9manipulated by the subroutines, and the subroutines only manipulate the data structures, then why are they
10semantically separate entities?

11

12Suppose that you have produced a data structure. You write subroutines to manipulate instances of this
13data structure. A user of your data structure may decide not to use the subroutines that you wrote. They
14write their own, and make many mistakes with your data structure. Who is going to be held accountable?
15Why you of course, the poor sot that created the data structure that provided to be impossible to use! What
16is preventing the programmer from bypassing the carefully constructed subroutines that you wrote to work
17with the data structure? In C, Nothing, nada, zilch, zippo. Your data structures are wide open to the
18marauding hordes of hackers. In C++, you can prevent users from using any subroutines except those that
19you provided to manipulate the data inside your data structure. This can be extremely useful in producing
20verifiably correct programs.

21

22The C++ class mechanism formalizes the practices of skilled programmers by enforcing data hiding and
23function exclusivity. C++ allows subroutines to be declared and defined WITHIN the context of a data
24structure. C++ also allows the programmer to specify what subroutines may act on what data structures.

1ch1p2.cpp	Demonstrates C++ using a traditional C structure and a subroutine to
2	work on instances of the structure
3	
4ch1p3.cpp	Demonstrates C++ using a class
5	private data and public member functions to access that data are shown
6	
7struct1.cpp	A C programmer ruining a program through invalid data put in YOUR data structure
8	
9struct2.cpp	C++ preventing the programmer from inserting invalid data through data hiding
10	
11strctev1.cpp	Rules, features usage of and ramifications of the
12	public, protected and private sections of a class
13	
14strctev2.cpp	CONSTRUCTORS, putting initial values into class instances
15	
16strctev3.cpp	Polymorphism and constructors
17	
18strctev4.cpp	Efficient constructors
19	
20static1.cpp	Static data in a class
21	
22static2.cpp	More static data in a class
23	
24strctev5.cpp	Error checking in the constructor
25	
26strctev6.cpp	Softer error checking in the constructor
27	
28strctev7.cpp	Multiple polymorphic constructors
29	
30strctev8.cpp	Polymorphism in a class
31	
32strctev9.cpp	External routines used by a class
33	
34destrct1.cpp	Simple constructors and destructors
35	
36destrct2.cpp	Multiple scopes and when things are destructed
37	
38destrct3.cpp	Arrays of objects being constructed and destructed
39	
40destrct4.cpp	Pointers in destructors and what gets destructed
41	the pointer, or the thing being pointed at
42	
43destrct5.cpp	Pointers in destructors, a different strategy
44	
45destrct6.cpp	Pointers in destructors, static data controlling destruction of pointed to area
46	
47destrct7.cpp	Does the destructed memory actually get destructed? or do we just lose
48	our pointer to it?
49	
50ch1p4.cpp	The role of public, protected and private in function visibility
51	
52strct10.cpp	Internalizing the error checking routines of strct9.cpp
53	
54strct11.cpp	What you do after the constructor is done.

```

1// ch1p2.cpp
2#include <stdio.h>           // get access to printf scanf
3#include <iostream.h>        // get access to cout and cin
4
5// a structure definition, the keyword struct works the same way as in C
6struct a
7{
8    int a;                  // a field, legal values are 0 to 10
9};
10
11// seta is a subroutine with error checking to ensure that a legal value is
12// put into the field in the structure of type struct a.
13// the question is, What is FORCING the user to use this routine?
14// Since they have unrestricted access to the data elements of the
15// structure, they can set a value into the field without using your
16// error checking routine, defeating the purpose of having the subroutine.
17void seta(struct a * sa, int ina)
18{
19    while ( ina < 0 || ina > 10 )
20    {
21        printf("%i is invalid, please enter number in range 0,10\n");
22        scanf("%i",&ina);
23    }
24    sa->a = ina;
25}
26
27main()
28{
29    struct a a1;            // create an instance of the data type struct a
30
31    // these first two sections use the variable a1 of type structa
32    // in conjunction with the subroutine seta that was designed to error
33    // check values going into an instance of a struct a
34    seta(&a1,3);             // this will call the subroutine that does the error
35                            // checking for the value you want to put in a1
36    printf("field a of a1 is %i \n",a1.a);
37
38    seta(&a1,-7);            // this will call subroutine that does error check
39    printf("field a of a1 is %i \n",a1.a);
40
41    // this code shows how a programmer can IGNORE the routine you wrote
42    // to put the values into instances of struct a
43    // in the first case, no harm is done
44    // in the second case, an illegal value arrives in the data structure
45    // EVEN THOUGH THERE IS A ROUTINE TO PREVENT THIS, NOTHING ENFORCED IT
46    a1.a = 10;               // programmer has direct access to fields of variables
47                            // of type struct a
48    printf("field a of a1 is %i \n",a1.a);
49
50    a1.a = -2;               // programmer has direct access to fields of variable
51    printf("field a of a1 is %i \n",a1.a);
52}

```

1Output From Running Program

2

3field a of a1 is 3

4

5

60 is invalid, please enter number in range 0,10

723

823 is invalid, please enter number in range 0,10

998

1098 is invalid, please enter number in range 0,10

115

12field a of a1 is 5

13

14

15

16field a of a1 is 10

17

18

19

20field a of a1 is -2

21

22

23THERE WAS NOTHING STOPPING THE PROGRAMMER FROM DIRECTLY ACCESSING THE

24DATA IN THE STRUCTURE. THEY WERE ABLE TO WANTONLY BYPASS ERROR CHECKING!!

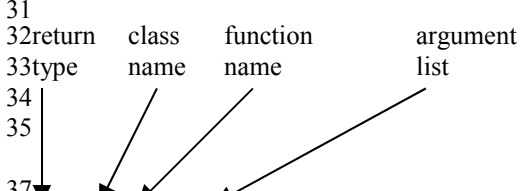
User uses subroutine and experiences error
checking the way we would hope they would

User uses direct access but luckily puts in
a valid value

User uses direct access and puts in an
invalid value

1// ch1p3.cpp

```
2#include <stdio.h>           // get access to printf scanf
3#include <iostream.h>        // get access to cout and cin
4
5// a class definition instead of a structure definition
6// the keyword private indicates that the field listed in the private area
7// can only be manipulated by the functions listed in the public area
8// the programmer does not have direct access to the fields in the private area
9// only the coder of the class has access to the fields
10// if the user wants to put a value in field a, they HAVE to go through the member function seta
11class a {
12    private:
13        int a;               // a field, legal values are 0 to 10
14    public:
15        void seta(int );     // a public member function to set a
16        void printa(void);   // a public member function to print a
17};
18
19// the function name is now expanded from seta to a::seta
20// the a:: identifies that fact that this is the seta function that belongs to the class a
21// note that unlike the seta from ch1p2.cpp, that no pointer to a struct a
22// is passed in by the programmer, the system passes a pointer for you
23// when a function is a member of a class, an instance of that class is BOUND
24// to the function call by the calling syntax, the BOUND variable is called
25// the INVOKING variable and its address is stored in the pointer variable
26// "this"
27
28// a sample call to this function would be a1.seta(-3);
29// the variable a1 would be BOUND to the call and its address would be stored
30// in a pointer "this"
31
32return    class    function    argument
33type      name     name        list
34
35
36
37
38void a::seta(int ina)
39{
40    while ( ina < 0 || ina > 10 )
41    {
42        printf("%i is invalid, please enter number in range 0,10\n");
43        scanf("%i",&ina);
44    }
45    // this was the pointer that got the address of the INVOKING variable
46    this->a = ina;
47}
48
49void a::printa(void)
50{
51    printf("The value of field a is %i\n",this->a);
52    return;
53}
```

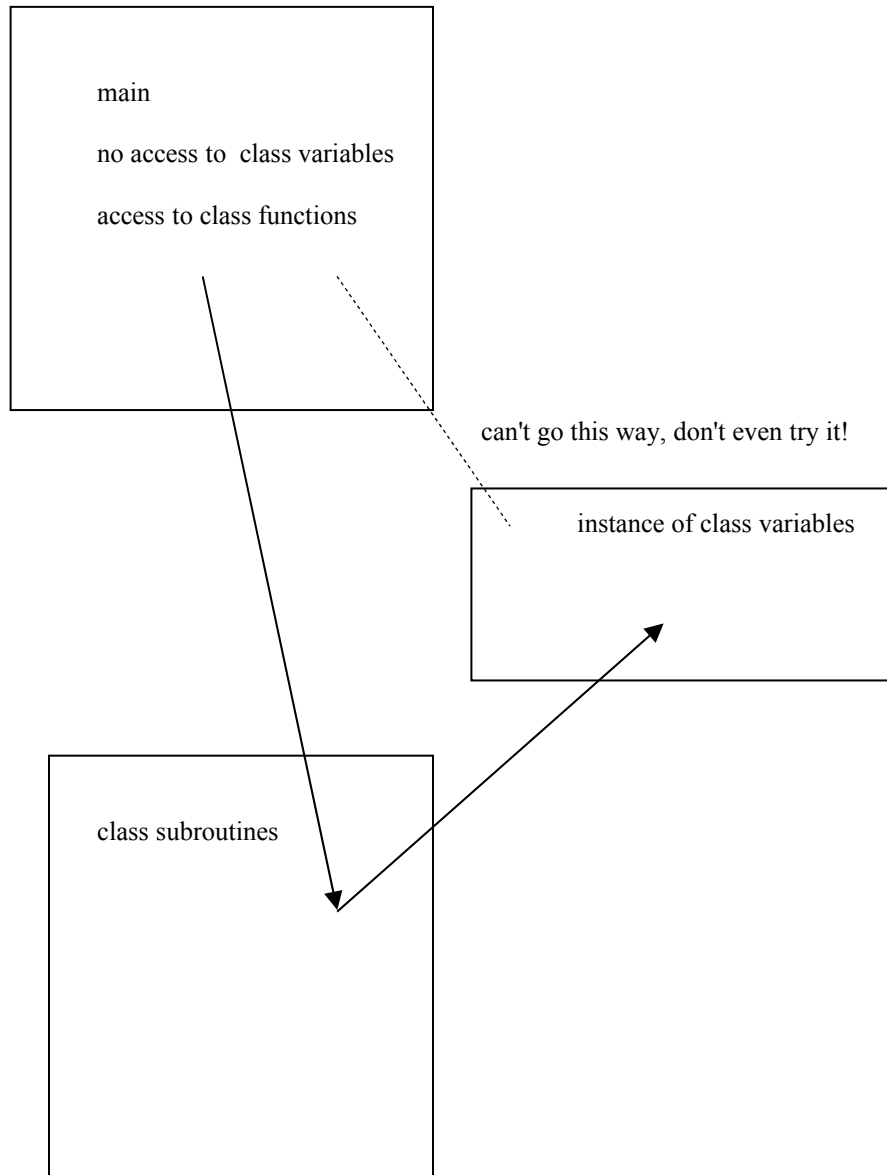


```

1main()
2{
3    // when declaring variables that are of a user defined class,
4    // the keyword class is not required
5    a a1;           // create an instance of the data type class a
6
7    // these first two sections use the variable a1 in conjunction with
8    // the subroutine seta that was designed to error check values going
9    // into an instance of a struct a
10   a1.seta(3);      // this will call the subroutine that does the error
11                   // checking for the value you want to put in a1
12   // because the field a is private, you can't print it from this code
13   // it is only available to member functions of the class
14   // this we have to use the member function printa
15   // printf("field a of a1 is %i \n",a1.a);
16   a1.printa();
17
18
19   a1.seta(-7);     // this will call subroutine that does error check
20   a1.printa();
21
22   // these lines will not compile, because a is a private field
23   // the error checking that you built into seta is ENFORCED
24   // remove the #if 0 and the #endif from the code and try to compile
25   // you will see the compiler error
26   // a::a is not accessible in function main()
27#if 0
28   a1.a = 10;
29   a1.a = -2;
30#endif
31}

```

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1// struct1.cpp

```
2// We have seen that unrestricted programmer access to structure fields is BAD
3// Because a structure can be made to take on invalid values, every subroutine
4// that deals with the structure type must have error checking included in it.
5// This is wasteful. It would be better if there was no way for an invalid value ever to get into
6// an instance of a data structure that you created
7
8#include <stdio.h>    // get access to printf and scanf
9#include <stdlib.h>   // get access to exit
10
11// account for the zero indexing, users typically say January is month 1
12char * months[13] =
13{
14    "fill", "January", "February", "March", "April", "May", "June",
15    "July", "August", "September", "October", "November", "Dec"
16};
17
18// Don't worry about leap year in this example
19// account for the zero indexing, users typically say January is month 1
20int days_per_month[13] = { 100, 31, 28, 31, 30, 31, 30, 31, 31, 30, 31, 30, 31 };
21
22struct d { int month, day, year; };    // typical struct definition
23
24void inc_date( struct d * );           // function to move to next date
25void print_date( struct d * );         // function to print what month it is
26
27main()
28{
29    // what will be the initial values for d1 and d2?? Whatever the SYSTEM decides.
30    struct d d1;                       // create an instance of an d
31    struct d d2;                       // create another instance of an d
32
33    d1.month = 12;
34    d1.day = 25;
35    d1.year = 1994;                   // a valid date has been initialized, okay
36
37    print_date(&d1);                   // display valid date
38    inc_date(&d1);                     // call f1 with a valid date
39    print_date(&d1);                   // call f2 with a valid date
40
41    d1.month = 98;                     // make a valid date into an invalid one
42                                        // there is nothing preventing the programmer from doing this
43    inc_date(&d1);                     // call the function with an invalid date, error checking required in routine
44    print_date(&d1);                   // call the function with an invalid date, error checking required in routine
45}
46
47
48
49
50
51
```

```

1// this function is supposed to move the date to the next day
2// it first has to check to see that the date passed to it is valid
3void inc_date ( struct d * ptr1 )
4{
5    // FORCED TO ERROR CHECK IN EVERY ROUTINE THAT DEALS WITH STRUCT D
6    if ( ptr1->year < 0 ) // make sure our year is valid
7    {
8        printf("Invalid year field, cannot print, exiting\n");
9        exit(-1);
10    }
11    // make sure our month is valid
12    if ( ptr1-> month < 1 || ptr1->month > 12 )
13    {
14        printf("Invalid month field, cannot print, exiting\n");
15        exit(-2);
16    }
17    // make sure our day is valid
18    if ( ptr1->day > days_per_month[ptr1->month] || ptr1->day < 1 )
19    {
20        printf("Invalid day field, cannot print, exiting\n");
21        exit(-3);
22    }
23    // now that we have a valid date, update it, wrapping if necessary
24    ptr1->day++;
25    if ( ptr1->day > days_per_month[ptr1->month] ) {
26        ptr1->day = 1; ptr1->month++;
27        if ( ptr1->month == 13 ) {
28            ptr1->month = 1;
29            ptr1->year++;
30        }
31    }
32    return;
33}
34
35void print_date( struct d * ptr1 ) {
36    // FORCED TO ERROR CHECK IN EVERY ROUTINE THAT DEALS WITH STRUCT D
37    if ( ptr1->year < 0 ) // make sure our year is valid{
38        printf("Invalid year encountered \n");
39        exit(-4);
40    }
41    if ( ptr1-> month < 1 || ptr1->month > 12 ) {
42        printf("Invalid month encountered \n");
43        exit(-5);
44    }
45    if ( ptr1->day > days_per_month[ptr1->month] || ptr1->day < 0 ) {
46        printf("Invalid day encountered\n");
47        exit(-6);
48    }
49    // only now that we have error checked the whole thing can we print
50    printf("%i of %s in %i\n",ptr1->day,months[ptr1->month],ptr1->year);
51    return;
52}

```

1Output From Running Program

2

325 of Dec in 1994

426 of Dec in 1994

5Invalid month field, cannot print, exiting

```

1// struct2.cpp
2#include <stdio.h>    // get access to printf
3#include <stdlib.h>    // get access to exit
4
5// the set_vals routine will deal with the zero indexing, we don't need a bogus entry for months[0]
6char * months[12] =
7{
8    "January", "February", "March", "April", "May", "June",
9    "July", "August", "September", "October", "November", "December"
10};
11
12// set_vals will deal with zero indexing, don't need a bogus entry in days_per_month[0]
13int days_per_month[12] = { 31, 28, 31, 30, 31, 30, 31, 31, 30, 31, 30, 31 };
14
15class d
16{
17    // only functions declared as part of class d are given access to
18    // month, day or year fields of instances of the class
19    private:
20        int month, day, year;
21
22    public:
23        void set_vals(int,int,int); // function to access fields
24        void inc_date( void );    // function to increment date
25        void print_date( void );  // function to print fields
26};
27
28main()
29{
30    // what will be the initial values for d1 and d2??
31    d d1;                // create an instance of an d
32
33    // these statements are illegal in C++ because month day and year
34    // are private elements of the struct d type of data
35    // d1.month = 12;
36    // d1.day = 25;
37    // d1.year = 1994;
38
39    // to set a date into d1, you have to use set_vals
40    d1.set_vals(12,25,1994); // apply the set_vals function to d1
41
42    d1.print_date();        // display valid date using f2 function of the variable d1
43
44    d1.inc_date();          // move d1 ahead to the next date
45    d1.print_date();        // display the new date
46
47    // try to set an invalid date into d1, it won't work!
48    d1.set_vals(123,456,-987);
49    d1.print_date();        // display valid date
50}
51
52
53
54
55

```

```

1// this function does NOT HAVE TO ERROR CHECK because there is no
2// way for an instance of type class d to get into an invalid state
3void d::inc_date()
4{
5    NO ERROR CHECKING REQUIRED HERE!!
6    this->day++;
7    if ( this->day > days_per_month[this->month] )
8    {
9        this->day = 1;
10       this->month++;
11       if ( this->month > 12 )
12       {
13           this->month = 0;
14           this->year++;
15       }
16    }
17    return;
18}
19
20// this function does not have to error check because there is no way
21// for a struct d instance to get invalid values
22void d::print_date( )
23{
24    NO ERROR CHECKING REQUIRED HERE!!!
25    printf("%i of %s in %i\n",this->day,months[this->month],this->year);
26    return;
27}

```

```

1// void is the return type
2// set_vals is the name of the function
3// a,b, and c are the expected parameters
4// we want to identify that this code is the code that implements the
5// function set_vals for the struct d data type, the d:: does this
6
7return   class   function   argument
8type     name    name      list
9         |       |         |
10        |       |         |
11        |       |         |
12        |       |         |
13        |       |         |
14        |       |         |
15void d::set_vals(int a, int b, int c )
16{
17    printf("Setvals got %i %i %i \n",a,b,c);
18    // when called via a call like d1.set_vals(1,2,3)
19    // C++ creates a pointer, "this", which is local to this subroutine
20    // this, in the call d1.set_vals(1,2,3) will end up with the addr of d1
21    // if set_vals were called via a call like d2.set_vals(3,4,5)
22    // then this would take on the address of d2
23    if ( c < 0 ) // make sure our year is valid
24    {
25        printf("Invalid year encountered\n");
26        exit(-1);
27    }
28
29    // make sure our month is valid
30    if ( a < 1 || a > 12 )
31    {
32        printf("Invalid month encountered\n");
33        exit(-2);
34    }
35
36    // make sure our day is valid
37    if ( b > days_per_month[a - 1] || b < 1 )
38    {
39        printf("Invalid day encountered\n");
40        exit(-3);
41    }
42
43    // if we get to here, then all the values checked out
44    this->month = a - 1; // account for array indexing starting at 0
45    this->day   = b;
46    this->year  = c;
47}

```

1Output From Running Program

2

3Setvals got 12 25 1994

425 of December in 1994

526 of December in 1994

6

7Setvals got 123 456 -987

8Invalid year encountered

1// strctev1.cpp

```
2// Now that we have seen the 2 rudiments of the class keyword,
3// the private and public sections, let's examine, in a somewhat exhaustive
4// manner, the rules, features, usage of and ramifications of the public,
5// private and protected sections of a class
6
7// A C++ class may have up to three sections:
8//      public  protected      private
9
10// each of these sections has different properties with respect
11// to the visibility of data fields and member functions
12// Let's examine the visibility of data fields first
13// There are two locations where a data field's visibility needs to be checked
14// First, within the code of a member function of the class
15// Second, within the code found in main, code that is NOT IN A MEMBER FUNCTION i.e. in main
16#include <stdio.h>
17
18class abc
19{
20    public:
21        int a;                // public data, visible everywhere
22        void set_vals(int,int,int); // public member function
23    protected:
24        int b;                // protected data, visible only in member functions
25    private:
26        int c;                // private data, visible only in member functions
27};
28
29void abc::set_vals(int A, int B, int C)
30{
31    printf("Address of bound object is %x \n",this);
32    printf("Before setting: a = %i \t b = %i \t c = %i \t \n", a,b,c);
33    this->a = A;                // public  data visible to member function
34    this->b = B;                // protected data visible to member function
35    this->c = C;                // private  data visible to member function
36    printf("After setting: a = %i \t b = %i \t c = %i \t \n", a,b,c);
37}
38
39main()
40{
41    abc a1;                    // create an instance of an abc, don't know what initial values will be
42
43    // a is a public data field, this line will compile
44    a1.a = 1;                  // attempt to individually assign values
45
46    // b is a protected data field, this line WILL NOT compile
47    // a1.b = 2;                // if you uncomment this line you will see compiler error message
48    // abc::b is not accessible in function main()
49
50    // c is a private data field, this line WILL NOT compile
51    // a1.c = 3;                // if you uncomment this line you will see compiler error message
52    // abc::c is not accessible in function main()
53
54
55
```

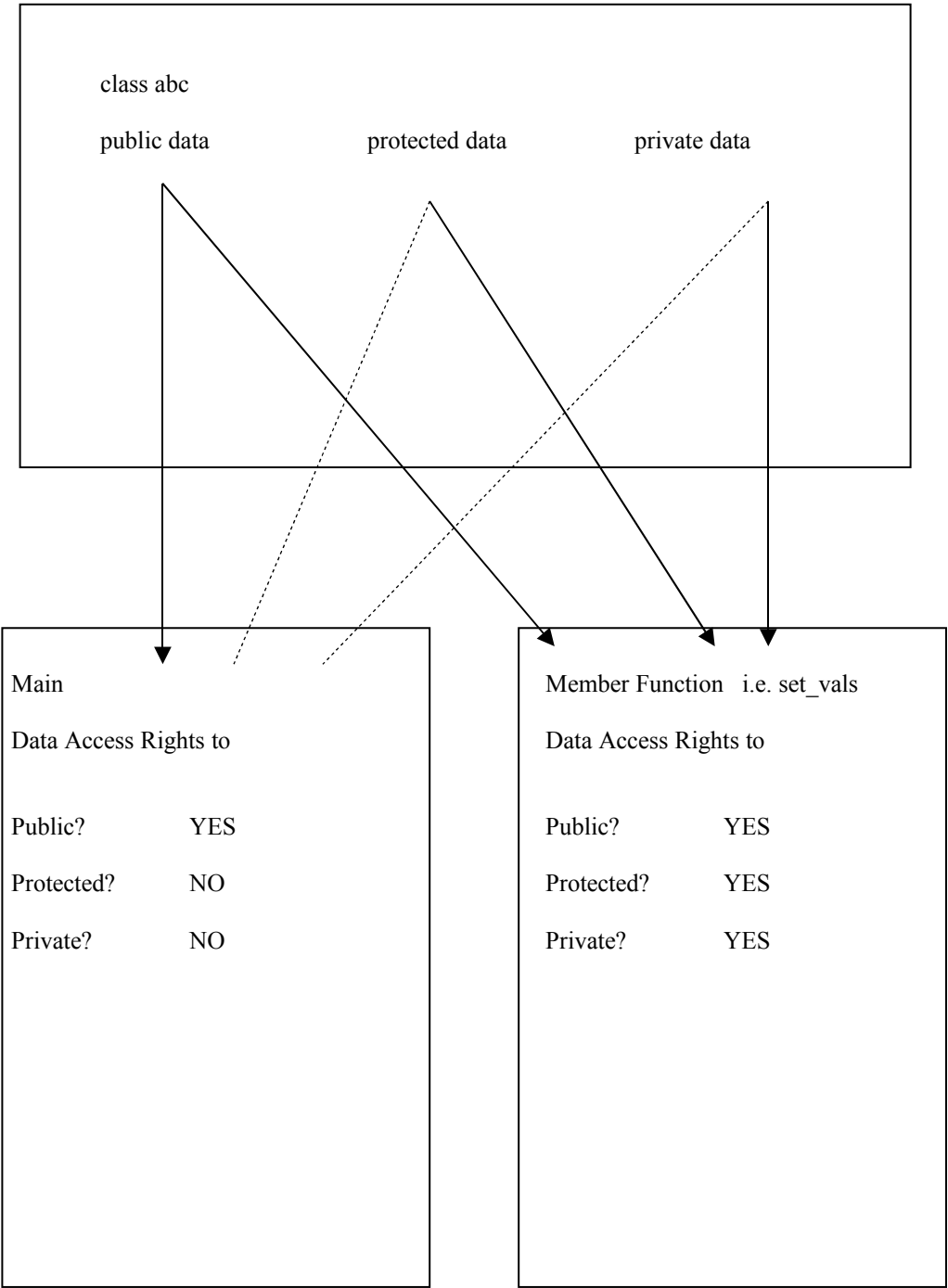


```

1  a1.set_vals(5,6,7); // this is how I could set the values of fields a b and c in a1 of class abc
2
3  // What if I tried to create another variable a2 of type abc?
4  // The question is, from this location, within main, not within
5  // the code of a member function, can I provide initial values?
6  // WITH WHAT WE KNOW NOW??
7  // NO. The field c is a private data element, therefore I cannot
8  // directly address it from here
9
10 // Question? Am I then prevented from providing initial values for an instance of a variable?
11 // NO. See the next program for Constructor code
12 // this line will not compile
13 // abc a2 = { 5,6,7 }; // create another instance of an abc
14 // if you uncomment this line you will see compiler error message
15 // Classes cannot be initialized with {} in function main()
16}
17
18Output From Running Program
19
20Address of bound object is fff0
21Before setting:  a = 1    b = 314  c = 1456
22After setting:   a = 5    b = 6    c = 7
23

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1// strctev2.cpp

```
2// the previous program raised the question about how do we assign initial
3// values to an instance of a class at initialization time?
4// this program introduces the CONSTRUCTOR code
5
6#include <stdio.h>
7
8class abc
9{
10     public:
11         int a;                // public data, visible everywhere
12         void set_vals(int,int,int); // public member function to assign
13                                   // values to an existing variable
14         // the name of the CONSTRUCTOR function must match the name of
15         // the class, the implied, default and in fact only possible
16         // return type for a CONSTRUCTOR function is a variable of the
17         // class to which the constructor function belongs
18         abc(int,int,int);      // public member function to assign
19                                   // values to a variable being created CONSTRUCTOR FUNCTION
20         void print_vals();     // public member function to print all three fields
21     protected:
22         int b;                // protected data, visible only in member functions
23     private:
24         int c;                // private data, visible only in member functions
25};
26
27// the return type is implied, defaulted, and fixed to be of type abc
28// no return statement is used, the use of "this" is not employed
29class      function      argument
30name      name          list
31
32
33
34
35abc::abc(int A, int B, int C )
36{
37     // This is the ideal location to do error checking of initial values
38     // see a subsequent program for this option
39     a = A;                // assign to the public field
40     b = B;                // assign to the protected field
41     c = C;                // assign to the private field
42}
43
44void abc::set_vals(int A, int B, int C)
45{
46     // this is also a very good place to do error checking of update values
47     // this will be done in a subsequent program
48     // NOTICE that this subroutine uses the this pointer, the subroutine
49     // above took advantage of "implied this" and saved typing this->
50     // for each field
51     this->a = A;           // public data visible to member function
52     this->b = B;           // protected data visible to member function
53     this->c = C;           // private data visible to member function
54}
```



```

1 void abc::print_vals()
2 {
3     printf("a = %i \t b = %i \t c = %i \n",this->a, this->b, this->c);
4 }
5
6 main()
7 {
8     // Now I try to create a2 and assign initial values to all three
9     // fields. The function abc, which is a member function of the class
10    // abc and which expects three integer arguments, will be called
11    // Because abc(int,int,int) is a member function, it has access to
12    // all three fields
13    abc a2(5,6,7);        // create an instance of an abc class object giving three integers as arguments
14    a2.print_vals();
15
16    // abc a1;           // this line is now a problem
17    // in the previous program, I provided NO CONSTRUCTOR
18    // therefore C++ provided one for me
19    // that DEFAULT NO ARGUMENT CONSTRUCTOR simply allocated the memory
20    // for the variables
21    // Now that I have provided a constructor function, I HAVE TO USE IT
22    // the line
23    // abc a1;
24    // says to build an abc but it doesn't provide
25    // the three integers that I said I would use to build one
26    // SO what do you do? See the next program
27 }
28
29 Output From Running Program
30 a = 5    b = 6    c = 7

```

1// strctev3.cpp

```
2// the previous program introduced a three argument constructor for the abc
3// class. We saw that this produced a problem, it caused the default no
4// argument constructor to become unavailable for our usage.
5// BUT what if WE WANTED a no argument constructor AND a three argument constructor?
6// IN C++ we can have two functions with the same name be members of the
7// same class as long as they have different argument lists
8// So in this program, I give two functions named abc
9// one is abc(int,int,int)
10// the other is abc(void)
11// both of these are CONSTRUCTOR functions
12// one is called when we give three integers when creating an abc
13// the other is called when we give NO arguments when creating an abc
14#include <stdio.h>           // get access to printf
15#include <iostream.h>        // get access to cout
16
17class abc
18{
19    public:
20        int a;                // public data, visible everywhere
21        void set_vals(int,int,int); // public member function to assign
22                                // values to an existing variable
23        // there are two functions with the name abc
24        // they can be told apart by their argument lists
25        abc(int,int,int);      // THREE ARGUMENT CONSTRUCTOR
26                                // public member function to assign values to a variable being
27                                // created CONSTRUCTOR FUNCTION
28        abc(void);             // ZERO ARGUMENT CONSTRUCTOR
29        void print_vals();      // public member function to print all three fields
30    protected:
31        int b;                 // protected data, visible only in member functions
32    private:
33        int c;                 // private data, visible only in member functions
34};
35
36// three argument constructor
37abc::abc(int A, int B, int C )
38{
39    // would do error checking here
40    cout << "Three Argument Constructor Called \n";
41    a = A;                     // assign to the public field
42    b = B;                     // assign to the protected field
43    c = C;                     // assign to the private field
44}
45// zero argument constructor
46abc::abc()
47{
48    // would do error checking here
49    cout << "NO ARGUMENT CONSTRUCTOR CALLED \n";
50    a = 1;                     // I just decided to put these three values into the fields
51    b = 2;                     // since you get to write the constructor, you get to decide what
52    c = 3;                     // initial values go in fields that otherwise would be set by the system
53}
```

```

1 void abc::set_vals(int A, int B, int C)
2 {
3     // would do error checking here
4     this->a = A;           // public  data visible to member function
5     this->b = B;           // protected data visible to member function
6     this->c = C;           // private  data visible to member function
7 }
8
9 void abc::print_vals()
10 {
11     // No need to do any error checking in this routine because all three avenues of approach
12     // to an instance of an abc, abc(int,int,int)  abc()  set_vals(int,int,int)  would be protected
13     // by error checking
14     printf("a = %i \t b = %i \t c = %i \n",this->a, this->b, this->c);
15 }
16
17 main()
18 {
19     abc a1;                // this line is no longer a problem
20                           // because we have a zero argument constructor in this application
21
22     a1.print_vals();        // show the initial values we assigned
23     a1.set_vals(10,20,30);  // call the member function
24     a1.print_vals();        // show the new values
25
26     // this line will also work because we have a three argument
27     // constructor for the class abc
28     abc a2(5,6,7);          // create another instance of an abc
29     a2.print_vals();        // show its initial values
30     a2.set_vals(-34,21,-98234); // call the member function
31     a2.print_vals();        // show the new values
32 }
33
34 Output From Running Program
35
36 NO ARGUMENT CONSTRUCTOR CALLED
37 a = 1    b = 2    c = 3
38 a = 10   b = 20   c = 30
39
40 Three Argument Constructor Called
41 a = 5    b = 6    c = 7
42 a = -34  b = 21   c = -98234
43

```

```

1// strctev4.cpp
2// the previous program introduced polymorphic constructors
3// this program introduces EFFICIENT constructors
4
5#include <stdio.h>
6#include <iostream.h>
7
8class abc
9{
10    public:
11        int a;                // public data, visible everywhere
12        void set_vals(int,int,int); // public member function to assign values to an existing variable
13
14        // Three argument constructor
15        abc(int,int,int);
16
17        // Zero argument constructor
18        abc(void);
19
20        void print_vals();
21
22    protected:
23        int b;                // protected data, visible only in member functions
24
25    private:
26        int c;                // private data, visible only in member functions
27};
28
29// this constructor uses INVOCATION LINE INITIALIZATION
30// all the memory for an instance of class abc is allocated before the first
31// executable statement of the constructor is performed
32// By using the a(A) syntax after the colon on the invocation line
33// the value of A is passed to the built in one arg C++ integer constructor
34// This is more efficient than assigning the value of A to a inside the
35// constructor code because if you don't say a(A) then the no arg C++
36// constructor is called and you are forced to do a = A. That is two steps
37// instead of one. It's like ordering a car, taking whatever color they send
38// you and then painting it red. If you wanted a red car, why didn't you
39// order a red car?
40
41// C++ provides one arg constructors for all predefined types
42// C++ provides on arg constructors for all user defined types
43// As soon as you provide any constructor for a user defined type, the C++ no arg constructor goes away
44

```

```

1
2          // this is the efficient method to initialize
3
4set variable a to value A   set variable b to value B   set variable c to value C
5by using C++ built in      by using C++ built in      by using C++ built in
6one arg integer            one arg integer            one arg integer
7constructor                constructor                constructor
8
9
10
11
12
13
14
15
16
17abc::abc(int A, int B, int C) : a(A), b(B), c(C)
18{
19    cout << "Three Argument Constructor Called \n";
20    // this would be the inefficient method
21    // a = A;    // system would have already assigned value to a, you would be re-assigning a value
22    // b = B;
23    // c = C;
24}
25
26// the more efficient INVOCATION LINE INITIALIZATION method for the no arg constructor
27// The ramifications of this type of initialization are small when you
28// just have pre-defined data types as the fields in your class
29// HOWEVER, when you have fields that themselves are classes, then the
30// ramifications can be quite large.
31abc::abc() : a(1), b(2), c(3)
32{
33    cout << "NO ARGUMENT CONSTRUCTOR CALLED \n";
34    // a = 1;    // this is the inefficient way
35    // b = 2;
36    // c = 3;
37}
38
39// this is NOT a constructor function, therefore it CANNOT do invocation line
40// initialization. Invocation line initialization is reserved for constructors
41void abc::set_vals(int A, int B, int C)
42{
43    this->a = A; // public   data visible to member function
44    this->b = B; // protected data visible to member function
45    this->c = C; // private  data visible to member function
46}
47
48void abc::print_vals()
49{
50    printf("a = %i \t b = %i \t c = %i \n", this->a, this->b, this->c);
51}

```



```

1main()
2{
3    abc a1;                // INVOKE THE ZERO ARGUMENT CONSTRUCTOR
4
5    a1.print_vals();        // show the initial values the constructor
6                            // assigned to the instance a1 of class abc
7    a1.set_vals(10,20,30);  // call the member function
8    a1.print_vals();        // show the new values
9
10   abc a2(5,6,7):          // INVOKE THE THREE ARGUMENT CONSTRUCTOR
11
12   a2.print_vals();        // show initial values
13   a2.set_vals(-34,21,-98234); // call the member function
14   a2.print_vals();        // show the new values
15
16}
17
18
19Output From Running Program
20
21NO ARGUMENT CONSTRUCTOR CALLED
22a = 1    b = 2    c = 3
23a = 10   b = 20   c = 30
24
25Three Argument Constructor Called
26a = 5    b = 6    c = 7
27a = -34  b = 21   c = -98234

```

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```
abc::abc(int A, int B, int C) : a(A) , b(B), c(C)
{
    efficient way to initialize
}
}
```

memory for the three ints is allocated here.

We provide initial values.

This is analogous to saying `int a = A int b = B; int c = C;`
when the integers are declared

```
abc::abc(int A, int B, int C)
{
a = A;          // you are resetting initial value provided by C++ no arg int constructor
ib = B;         // again, you are re-assigning a value into b
c = C;          // Too late, you are slow, you are bad, you are an
                INEFFICIENT PROGRAMMER
```

why would you write:

```
int a;
a = 5;
```

when you could write

```
int a = 5;
```



1// static1.cpp

```
2// classes can have STATIC variables
3// A static variable is SHARED amongst all instances of variables of that class
4// The static variable should not be initialized in the constructor of a class
5// because every object that is created would then be initializing the shared variable
6
7// The shared variable should be initialized just before you start main
8// The shared variable still obeys the public, protected, private rules of any other variable
9
10// Shared variables are very useful for tracking how many objects were created
11// for determining how many times some subroutine was called and so on
12// for sharing information amongst every instance of a user defined type
13
14#include <iostream.h>
15
16class abc
17{
18    public:
19        abc();                // no arg constructor
20        void print_vals();
21    private:
22        static int num_of_abcs;    // static variable, private data, only visible to members
23                                    // will keep track of how many abcs are created
24
25        int a,b,c;                // private data, visible only in member functions
26};
27
28abc::abc()
29{
30    cout << "No arg constructor called\n";
31    cout << "Current value of num_of_abcs is " << num_of_abcs << endl;
32    num_of_abcs++;
33    a = 1 * num_of_abcs;          // uses num_of_abcs to do something, your programs would
34    b = 2 * num_of_abcs;          // likely have more interesting uses of static data than does
35    c = 3 * num_of_abcs;          // this teaching program
36}
37
38void abc::print_vals()
39{
40    cout << "Values are: \n";
41    cout << "a " << a
42        << " b " << b
43        << " c " << c << endl;
44
45    cout << "static field num_of_abcs has: " << num_of_abcs << endl;
46}
47
48int abc::num_of_abcs = 0;        // initialize the static data
```

```

1main()
2{
3    abc a1;    // create an instance of an abc
4    a1.print_vals();
5
6    abc a2;    // create a second one
7    a2.print_vals();
8
9    abc a3[4];    // create four more
10
11    for ( int i = 0; i < 4; i++ )
12        a3[i].print_vals();
13
14        // you could not do this, because num_of_abcs was declared as private data
15        // abc::num_of_abcs = 10;
16}
17
18Output From Running Program
19
20No arg constructor called
21Current value of num_of_abcs is 0
22Values are:
23a 1  b 2  c 3
24static field num_of_abcs has: 1
25
26No arg constructor called
27Current value of num_of_abcs is 1
28Values are:
29a 2  b 4  c 6
30static field num_of_abcs has: 2
31
32No arg constructor called
33Current value of num_of_abcs is 2
34No arg constructor called
35Current value of num_of_abcs is 3
36No arg constructor called
37Current value of num_of_abcs is 4
38No arg constructor called
39Current value of num_of_abcs is 5
40Values are:
41a 3  b 6  c 9
42static field num_of_abcs has: 6
43Values are:
44a 4  b 8  c 12
45static field num_of_abcs has: 6
46Values are:
47a 5  b 10 c 15
48static field num_of_abcs has: 6
49Values are:
50a 6  b 12 c 18
51static field num_of_abcs has: 6
52

```

1// static2.cpp

2// this program shows what happens if you initialize the shared variable

3// in the constructor, which is the wrong place

```
4
5#include <iostream.h>
6
7class abc
8{
9    public:
10        abc();                // no arg constructor
11        void print_vals();
12    private:
13        static int num_of_abcs; // static variable
14
15        int a,b,c;             // private data, visible only in member functions
16};
17
18abc::abc()
19{
20    num_of_abcs = 0;           // num_of_abcs will be set to zero by EVERY abc that is created
21    cout << "No arg constructor called\n";
22    cout << "Current value of num_of_abcs is " << num_of_abcs << endl;
23    a = 1 * num_of_abcs;
24    b = 2 * num_of_abcs;
25    c = 3 * num_of_abcs;
26}
27
28void abc::print_vals()
29{
30    cout << "Values are: \n";
31    cout << "a " << a
32        << " b " << b
33        << " c " << c << endl;
34
35    cout << "static field num_of_abcs has: " << num_of_abcs << endl;
36}
37
38main()
39{
40    abc a1;                    // create an instance of an abc, initializes num_of_abcs to zero
41    a1.print_vals();
42
43    abc a2;                    // create a second one, sets num_of_abcs back to zero
44    a2.print_vals();
45
46    abc a3[4];                 // create four more, each one sets num_of_abcs back to zero
47
48    for ( int i = 0; i < 4; i++ )
49        a3[i].print_vals();
50}
```

1Output From Running Program
2
3No arg constructor called
4Current value of num_of_abcs is 0
5Values are:
6a 0 b 0 c 0
7static field num_of_abcs has: 0
8No arg constructor called
9Current value of num_of_abcs is 0
10Values are:
11a 0 b 0 c 0
12
13static field num_of_abcs has: 0
14No arg constructor called
15Current value of num_of_abcs is 0
16No arg constructor called
17Current value of num_of_abcs is 0
18No arg constructor called
19Current value of num_of_abcs is 0
20No arg constructor called
21Current value of num_of_abcs is 0
22
23Values are:
24a 0 b 0 c 0
25static field num_of_abcs has: 0
26Values are:
27a 0 b 0 c 0
28
29static field num_of_abcs has: 0
30Values are:
31a 0 b 0 c 0
32
33static field num_of_abcs has: 0
34Values are:
35a 0 b 0 c 0
36
37static field num_of_abcs has: 0
38

1// strctev5.cpp

```
2// The constructor provides the perfect place to error check any values
3// that someone might want to put into a variable of your defined type
4// For example, in C, if you have a date data type, is there anything
5// keeping someone from creating a data variable with the values -1/-2/-3 ?
6// NO
7// In C++, we will be able to perform error checking in the constructor
8
9char * months[12] =
10{
11    "January", "February", "March", "April", "May", "June", "July",
12    "August", "September", "October", "November", "December"
13};
14
15int days_per_month[12] = { 31, 28, 31, 30, 31, 30, 31, 31, 30, 31, 30, 31 };
16
17#include <iostream.h>
18#include <stdio.h>
19#include <stdlib.h>
20
21class date
22{
23    public:
24        date(int,int,int);        // function with same name as data type is a CONSTRUCTOR
25        void print_date();        // function to display a date
26    private:
27        int month;                // DOMAIN    1 - 12
28        int day;                  // DOMAIN    depends on month
29        int year;                 // DOMAIN    0 to whatever
30};
31
32main()
33{
34    date d1(12,23,1993);          // this is valid, it will work
35    d1.print_date();
36
37    date d2(-1,-3,-4);            // this is an attempt to create an invalid
38                                    // instance of a date object, it will cause
39                                    // program termination because the constructor
40                                    // does error checking and the class designer
41                                    // decided that an attempt to create an invalid
42                                    // object was means for termination. Softer
43                                    // approaches to error handling are up to the
44                                    // individual class designer. That's part of
45                                    // the whole point of being able to write
46                                    // constructor code
47}
```

```

1// return type          void
2// complete function name date::print_date
3// argument list        ()
4void date::print_date()
5{
6    cout << "In member_print_date \n";
7    cout << " month is " << this->month <<
8        " day is " << this->day <<
9        " year is " << this->year << endl;
10}
11
12// return type          none explicitly defined, abc by definition
13// complete function name date::date
14// argument list        three integers for month, day, year
15date::date(int m, int d, int y)
16{
17    // no pointer "this" is available for this function
18    // because this function is creating the instance of the abc variable
19    // this function implicitly returns a variable of the abc type
20    cout << "The three argument constructor has been called " << endl;
21
22    // error check for a valid year, if the year is invalid
23    // TERMINATE the program. If you were coding this constructor you
24    // may have chosen a softer approach to error handling, this is
25    // demonstrated in subsequent programs.
26    if ( y < 0 )
27    {
28        cout << "Your desired year " << y << " is invalid " << endl;
29        exit(-1);
30    }
31    if ( m < 1 || m > 12 )
32    {
33        cout << "Your desired month " << m << " is invalid " << endl;
34        exit(-2);
35    }
36    if ( d < 1 || d > days_per_month[m - 1] )
37    {
38        cout << "Your desired day " << d << " is invalid " << endl;
39        exit(-3);
40    }
41    // if we make it through all the checks assign the fields
42    day = d;
43    month = m - 1; // account for zero indexing
44    year = y;
45    return;
46}
47Output From Running Program
48The three argument constructor has been called
49In member_print_date
50    month is 11    day is 23    year is 1993
51
52The three argument constructor has been called
53Your desired year -4 is invalid

```


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class date

public

date

print_date

constructor

display function

private

month

day

year

only accessible through member functions

can't just assign values to these things

so

if you error check correctly at initialization time

and code your subroutines right

you don't have to error check anywhere else in program

constructor

error checks month

error checks day

error checks year

assigns the values

print_date subroutine

no need to error check

impossible to have invalid values in a date instance

1// strctev6.cpp

```
2// In strctev5.cpp, if the value the user wanted to put into the
3// date object to be constructed was invalid, we took drastic steps
4// and exited the program. Perhaps we would like to allow the user
5// to re-enter the dates for an object of the class or perhaps we would
6// just like to assign known valid values, either of these approaches
7// has merits. This program illustrates error checking loops in the constructor
8
9char * months[12] =
10{
11    "January", "February", "March", "April", "May", "June", "July",
12    "August", "September", "October", "November", "December"
13};
14
15int days_per_month[12] = { 31, 28, 31, 30, 31, 30, 31, 31, 30, 31, 30, 31 };
16
17#include <iostream.h>
18#include <stdio.h>
19#include <stdlib.h>
20
21class date
22{
23    public:
24        date(int,int,int);          // function with same name as
25                                    // data type is a CONSTRUCTOR
26        void print_date();          // function to display a date
27    private:
28        int month;                  // DOMAIN    1 - 12
29        int day;                    // DOMAIN    depends on month
30        int year;                   // DOMAIN    0 to whatever
31};
32
33main()
34{
35    date d1(12,23,1993);           // this is valid, it will work
36    d1.print_date();
37
38    date d2(-1,-3,-4);             // this is invalid, it will cause the error checking to be invoked
39    d2.print_date();
40}
41
42// return type                void
43// complete function name      date::print_date
44// argument list                ()
45void date::print_date()
46{
47    // this is the pointer that has the address of the object that was BOUND to this call
48    cout << "In member_print_date \n";
49    cout << " month is " << this->month <<
50        " day is " << this->day <<
51        " year is " << this->year << endl;
52}
```

```

1// return type           none explicitly defined, abc by definition
2// complete function name date::date
3// argument list         three integers for month, day, year
4date::date(int m, int d, int y) {
5    cout << "The three argument constructor has been called " << endl;
6    cout << "Input arguments were " << m << " " << d << " " << y << endl;
7    if ( y < 0 )
8    {
9        int tempy = y;    // create a local variable
10
11        while ( tempy < 0 )
12        {
13            cout << "Year " << tempy << " is invalid " << endl;
14            cout << "Please enter a year greater than 0 ";
15            cin >> tempy;
16        }
17        cout << "Valid y of " << tempy << " accepted " << endl;
18        y = tempy;
19    }
20    if ( m < 1 || m > 12 ) {
21        int tempm = m;
22        while ( tempm < 1 || tempm > 12 )
23        {
24            cout << "Month " << tempm << " is invalid " << endl;
25            cout << "Please enter a month in the range 1 - 12 ";
26            cin >> tempm;
27        }
28        m = tempm;    // account for zero indexing
29        cout << "Valid m of " << tempm << " accepted " << endl;
30    }
31
32    if ( d < 1 || d > days_per_month[m - 1] )
33    {
34        int tempd = d;
35        while ( tempd < 1 || tempd > days_per_month[m - 1] )
36        {
37            cout << "Day " << tempd << " is invalid " << endl;
38            cout << "Please enter a day in the range 1 - "
39                << days_per_month[m - 1] << " ";
40            cin >> tempd;
41        }
42        d = tempd;
43        cout << "Valid d of " << tempd << " accepted " << endl;
44    }
45
46    // once we make it through all the checks assign the fields
47    day = d;    // could have been written this->day = d
48    month = m - 1;    // could have been written this->month = m
49    year = y;    // could have been written this->year = y
50    return;
51}

```

1Output From Running Program

```
2
3The three argument constructor has been called
4Input arguments were 12 23 1993
5In member_print_date
6month is 11 day is 23 year is 1993
7The three argument constructor has been called
8Input arguments were -1 -3 -4
9Year -4 is invalid
10Please enter a year greater than 0 Valid y of 45 accepted
11Month -1 is invalid
12Please enter a month in the range 1 - 12 Month 15 is invalid
13Please enter a month in the range 1 - 12 Month -7 is invalid
14Please enter a month in the range 1 - 12 Valid m of 3 accepted
15Day -3 is invalid
16Please enter a day in the range 1 - 31 Day 42 is invalid
17Please enter a day in the range 1 - 31 Valid d of 12 accepted
18In member_print_date
19month is 2 day is 12 year is 45
```

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Error Checking Loop
for year

Error checking loop
for month

Error checking loop
for days in month
Assign valid entries to date object

print_date
no error checking

1// strctev7.cpp

```
2// We have already seen that it is possible to have a function with
3// one name and two different argument lists. This is known as
4// a polymorphic function. Can we have multiple polymorphic constructors?
5// Yes!
6// The program below will allow you create an instance of a date class variable
7// by providing either no, one, two or three arguments. Each of the
8// constructors will either decide to do some error checking or to just
9// assign some date to fill in the missing arguments.
10// Notice that there is duplication of effort in the error checking.
11// Perhaps we should consider making subroutines that all they do is error checking and allow
12// the constructors to call these routines as they see fit.
13
14// What your constructors would do would depend on you and your application
15// Because you are writing the constructors for your class
16// You can control what happens when a variable of your class is created
17// This is a BIG ADVANTAGE of C++ over C
18
19char * months[12] =
20{
21    "January", "February", "March", "April", "May", "June", "July",
22    "August", "September", "October", "November", "December"
23};
24
25int days_per_month[12] = { 31, 28, 31, 30, 31, 30, 31, 31, 30, 31, 30, 31 };
26
27#include <iostream.h>
28#include <stdio.h>
29#include <stdlib.h>
30
31class date
32{
33    public:
34        date();           // zero argument constructor
35        date(int);        // one argument constructor
36        date(int,int);     // two argument constructor
37        date(int,int,int); // three argument constructor
38
39        void print_date(); // function to display a date
40    private:
41        int month;         // DOMAIN    1 - 12
42        int day;           // DOMAIN    depends on month
43        int year;          // DOMAIN    0 to whatever
44};
```

```

1main()
2{
3    date d1;           // create a var d1 of type date specifying no args
4    d1.print_date();
5
6    date d2(1994);      // create a var d2 of type date specifying one arg
7    d2.print_date();
8
9    date d3(3,1994);    // create a var d3 of type date specifying two args
10   d3.print_date();
11
12   date d4(3,1,1994);   // create a var d4 of type date specifying three args
13   d4.print_date();
14}

```

```

1// return type                void
2// complete function name      date::print_date
3// argument list               ()
4void date::print_date()
5{
6    cout << "In member_print_date \n";
7    cout << " month is " << this->month <<
8        " day is " << this->day <<
9        " year is " << this->year << endl << endl;
10}
11
12// no argument constructor, no error checking required, just assign some date
13date::date()
14{
15    cout << "Welcome to the no arg constructor " << endl;
16    // this is the implementation of the no arg constructor
17    // I have decided to put in today's date
18    // so however your system retrieves the system date let's assume
19    // those values ended up in the variable m,d,y okay?
20    int m = 6, d = 6, y = 1944;
21    month = m;    day = d;    year = y;
22}
23
24// one argument constructor, error checking for the year implemented
25date::date(int y)
26{
27    // this is the one argument constructor
28    // I have decided to interpret the one arg as the year
29    // I have decided to error check it
30    // I have decided to set the day and month to January first
31    // Why, because I felt like it, you might decide to do something
32    // different, that's the whole point of constructors
33    // You get to decide on the initial values, not the system or someone
34    // else, you get to be in control
35    cout << "The one argument constructor has been called " << endl;
36    if ( y < 0 )
37    {
38        int tempy = y;    // create a local variable
39
40        while ( tempy < 0 )
41        {
42            cout << "Year " << tempy << " is invalid " << endl;
43            cout << "Please enter a year greater than 0 ";
44            cin >> tempy;
45        }
46        cout << "Valid y of " << tempy << " accepted" << endl;
47        y = tempy;
48    }
49    month = 1;
50    day = 1;
51    year = y;
52}

```

```

1// two argument constructor with error checking
2date::date(int m, int y)
3{
4    // this is the two argument constructor
5    // I have decided to interpret the second arg as the year
6    // I have decided to interpret the first arg as the month
7    // I have decided to error check them both
8    // I have decided to set the day to the first of the month
9    cout << "The two argument constructor has been called " << endl;
10   if ( y < 0 )
11   {
12       int tempy = y;    // create a local variable
13
14       while ( tempy < 0 )
15       {
16           cout << "Year " << tempy << " is invalid " << endl;
17           cout << "Please enter a year greater than 0 ";
18           cin >> tempy;
19       }
20       cout << "Valid y of " << tempy << " accepted" << endl;
21       y = tempy;
22   }
23   if ( m < 1 || m > 12 )
24   {
25       int tempm = m;
26       while ( tempm < 1 || tempm > 12 )
27       {
28           cout << "Month " << tempm << " is invalid " << endl;
29           cout << "Please enter a month in the range 1 -12 ";
30           cin >> tempm;
31       }
32       cout << "Valid m of " << tempm << " accepted" << endl;
33       m = tempm;
34   }
35   month = m;
36   day = 1;
37   year = y;
38}

```



```

1// three argument constructor with error checking
2date::date(int m, int d, int y)
3{
4    cout << "The three argument constructor has been called " << endl;
5    if ( y < 0 )
6    {
7        int tempy = y;    // create a local variable
8
9        while ( tempy < 0 )
10        {
11            cout << "Year " << tempy << " is invalid " << endl;
12            cout << "Please enter a year greater than 0 ";
13            cin >> tempy;
14        }
15        cout << "Valid y of " << tempy << " accepted" << endl;
16        y = tempy;
17    }
18    if ( m < 1 || m > 12 )
19    {
20        int tempm = m;
21        while ( tempm < 1 || tempm > 12 )
22        {
23            cout << "Month " << tempm << " is invalid " << endl;
24            cout << "Please enter a month in the range 1 -12 ";
25            cin >> tempm;
26        }
27        cout << "Valid m of " << tempm << " accepted" << endl;
28        m = tempm;
29    }
30    if ( d < 1 || d > days_per_month[m - 1] )
31    {
32        int tempd = d;
33        while ( tempd < 1 || tempd > days_per_month[m - 1] )
34        {
35            cout << "Day " << tempd << " is invalid " << endl;
36            cout << "Please enter a day in the range 1 - "
37                << days_per_month[m - 1] << " ";
38            cin >> tempd;
39        }
40        cout << "Valid d of " << tempd << " accepted" << endl;
41        d = tempd;
42    }
43
44    // once we make it through all the checks assign the fields
45    day = d;        // this->day = d
46    month = m;      // this->month = m
47    year = y;       // this->year = y
48    return;
49}

```

2

4In member_print_date

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8In member_print_date

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12In member_print_date

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16In member_print_date

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1.

1

1// strctev8.cpp

```
2// Does polymorphism apply only to constructors for a data type? No.
3// This program has the same four constructors as strctev7.cpp but it
4// also has three print_date routines
5// To save space, I have removed the error checking code for the constructors
6// in this application
7
8char * months[12] =
9{
10    "January", "February", "March", "April", "May", "June", "July",
11    "August", "September", "October", "November", "December"
12};
13
14int days_per_month[12] = { 31, 28, 31, 30, 31, 30, 31, 31, 30, 31, 30, 31 };
15
16#include <iostream.h>
17#include <stdio.h>
18#include <stdlib.h>
19
20class date
21{
22    public:
23        date();           // no argument constructor
24        date(int);        // one argument constructor
25        date(int,int);    // two argument constructor
26        date(int,int,int); // three argument constructor
27
28        void print_date(); // function to display a date
29        void print_date(int); // how many times to print date before printing the date
30                               // also print month instead of month #
31        void print_date(char*); // string to be displayed with date
32    private:
33        int month;        // DOMAIN    1 - 12
34        int day;          // DOMAIN    depends on month
35        int year;         // DOMAIN    0 to whatever
36};
37
38main()
39{
40    date d1;              // create a var d1 of type date specifying no args
41    d1.print_date( (int) 3); // call the one int arg print_date func
42    d1.print_date();        // call the no arg print_date function
43    d1.print_date("Today's date is "); // call the one char* arg func
44
45    date d2(1994);        // create a var d2 of type date specifying one arg
46    d2.print_date( (int) 4); // call the one int arg print_date func
47    d2.print_date();        // call the no arg print_date function
48    d2.print_date("Au'jour d'hui c'est "); // call the one char* arg func
49
50    date d3(3,1994);      // create a var d3 of type date specifying two args
51    d3.print_date(3);
52    d3.print_date();
53    d3.print_date("nichi wa ")
```

```

1      date d4(3,1,1994);                // create a var d4 of type date specifying three args
2      d4.print_date(7);
3      d4.print_date();
4      d4.print_date("Hoyte ist ");
5}

6
7// return type                void
8// complete function name      date::print_date
9// argument list                ()
10void date::print_date()
11{
12    cout << "In print_date \n";
13    cout << " month is " << this->month <<
14        " day is " << this->day <<
15        " year is " << this->year << endl << endl;
16}

17
18// return type                void
19// complete function name      date::print_date
20// argument list                (one integer )
21void date::print_date(int x)
22{
23    cout << "In print_date(int) \n";
24
25    for ( int i = 0; i < x; i++ )
26        cout << months[this->month -1] << " " << this->day
27        << " " << this->year << endl;
28}

29
30// return type                void
31// complete function name      date::print_date
32// argument list                ( one pointer to character )
33void date::print_date(char * s)
34{
35    cout << "In print_date(char * ) \n";
36    cout << s << months[this->month -1] << " " << this->day
37        << " " << this->year << endl << endl;
38}

39
40the four date constructors are identical to strtrev7.cpp
41date::date()
42date::date(int y)
43date::date(int m, int y)
44date::date(int m, int d, int y)

```

```

1Output From Running Program
2
3In print_date(int)
4July 22 1961
5July 22 1961
6July 22 1961
7In print_date
8month is 7 day is 22 year is 1961
9
10In print_date(char * )
11Today's date is July 22 1961
12
13In print_date(int)
14January 1 1994
15January 1 1994
16January 1 1994
17January 1 1994
18In print_date
19month is 1 day is 1 year is 1994
20
21In print_date(char * )
22Au'jour d'hui c'est January 1 1994
23
24In print_date(int)
25March 1 1994
26March 1 1994
27March 1 1994
28In print_date
29month is 3 day is 1 year is 1994
30
31In print_date(char * )
32nichi wa March 1 1994
33
34In print_date(int)
35March 1 1994
36March 1 1994
37March 1 1994
38March 1 1994
39March 1 1994
40March 1 1994
41March 1 1994
42In print_date
43month is 3 day is 1 year is 1994
44
45In print_date(char * )
46Hoyte ist March 1 1994
47
48

```

1// strctev9.cpp

```
2// Each of the constructors in strctev7.cpp did similar error checking
3// Wouldn't it make sense to have common routines that could error check for
4// the year, month or day fields that any of the constructors could call?
5// Also, wouldn't those functions be useful to the set_vals routines?
6// Yes. This program shows that constructors can call subroutines
7// Note that these subroutines aren't member functions of the date class
8// They are regular subroutines like you are used to from C
9// They DO NOT have an object bound to them
10// Maybe they SHOULD be member functions. Does anyone else have any need to call these functions?
11// If no one else has a need to call them, then they should be member functions, furthermore,
12// they should be PRIVATE member functions that can only be called by other member functions.
13
14int get_year(int);           // accept a year, error check it, return valid year
15int get_month(int);         // accept a month, error check it, return valid month
16int get_day(int,int);       // accept a day and month, error check day, return
17
18char * months[12] =
19{
20    "January", "February", "March", "April", "May", "June", "July",
21    "August", "September", "October", "November", "December"
22};
23int days_per_month[12] = { 31, 28, 31, 30, 31, 30, 31, 31, 30, 31, 30, 31 };
24#include <iostream.h>
25#include <stdio.h>
26#include <stdlib.h>
27
28class date
29{
30    public:
31        date();               // no argument constructor
32        date(int);            // one argument constructor
33        date(int,int);        // two argument constructor
34        date(int,int,int);    // three argument constructor
35
36        void print_date();    // function to display a date
37    private:
38        int month;           // DOMAIN    1 - 12
39        int day;             // DOMAIN    depends on month
40        int year;            // DOMAIN    0 to whatever
41};
42main()
43{
44    date d1;                 // no arg constructor invoked
45    d1.print_date();
46    date d2(1994);           // call 1 arg constructor, valid values
47    d2.print_date();
48    date d3(-3,1994);        // call 2 arg constructor, invalid values
49    d3.print_date();
50    date d4(-3,121,-9);      // call 3 arg constructor, invalid values
51    d4.print_date();
52}
```

```

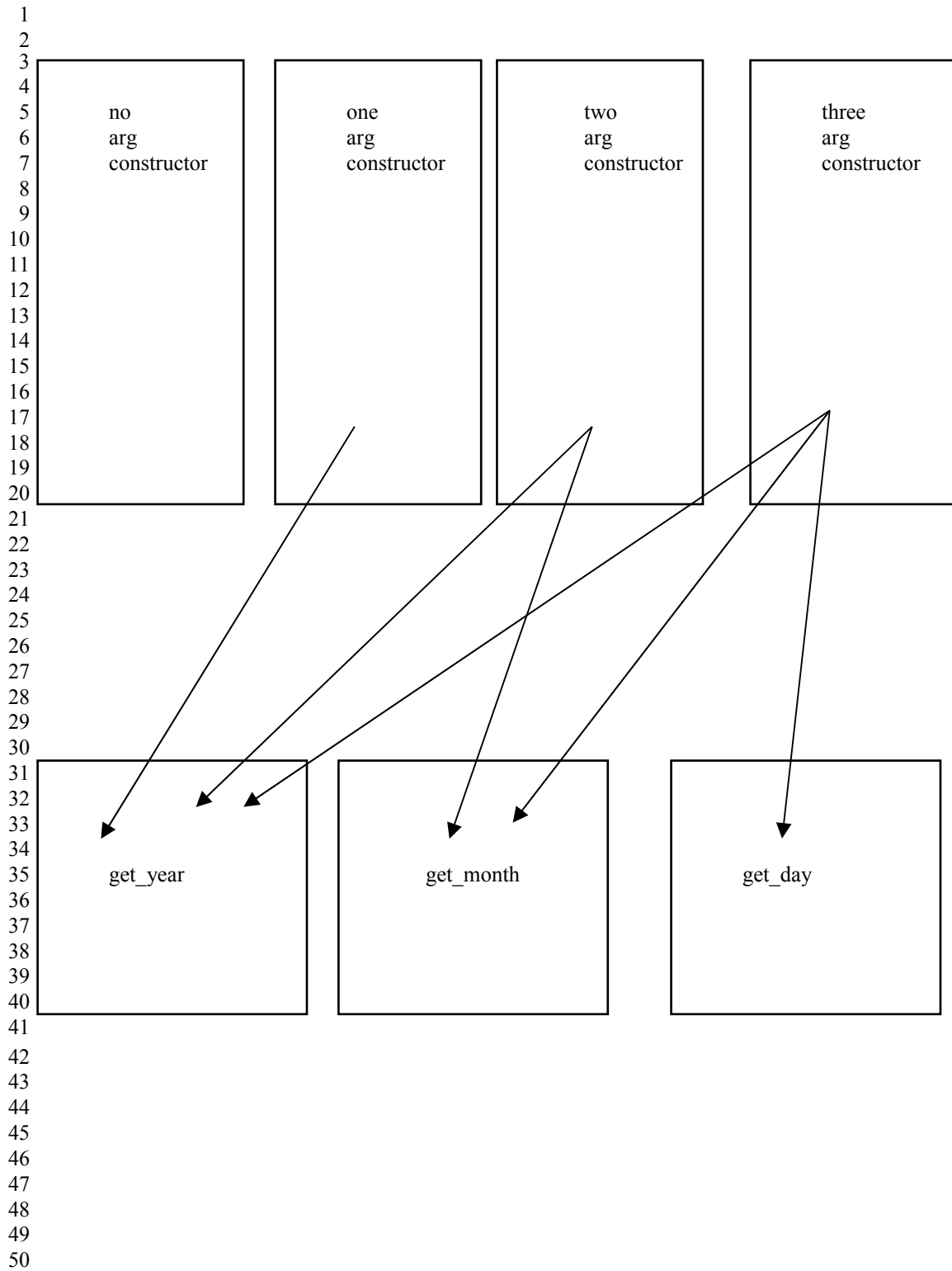
1 void date::print_date()
2 {
3     cout << " month is " << this->month <<
4         " day is " << this->day <<
5         " year is " << this->year << endl << endl;
6 }
7
8 // The three error checking logic loops are made into seperate routines that can be
9 // called from the constructors, this has the effect of making the overall
10 // amount of code smaller since the error checking doesn't have to be repeated
11 // in each of the constructors. It does make it slower however, because there
12 // is the additional overhead of additional functional calls from within the
13
14 // Does it make sense to have these error checking subroutines visible to the
15 // user of the class which you are designing? Perhaps not.
16 // In the next program, strct11.cpp, We show how these routines can be
17 // HIDDEN from the casual user but left visible to the class designer
18
19 int get_year(int y)
20 {
21     if ( y < 0 )
22     {
23         int tempy = y;    // create a local variable
24
25         while ( tempy < 0 )
26         {
27             cout << "Year " << tempy << " is invalid " << endl;
28             cout << "Please enter a year greater than 0 ";
29             cin >> tempy;
30         }
31         cout << "Valid y of " << tempy << " accepted" << endl;
32         y = tempy;
33     }
34     return(y);
35 }
36
37 int get_month(int m)
38 {
39     if ( m < 1 || m > 12 )
40     {
41         int tempm = m;
42         while ( tempm < 1 || tempm > 12 )
43         {
44             cout << "Month " << tempm << " is invalid " << endl;
45             cout << "Please enter a month in the range 1 -12 ";
46             cin >> tempm;
47         }
48         cout << "Valid m of " << tempm << " accepted" << endl;
49         m = tempm;
50     }
51     return(m);
52 }

```

```

1 int get_day(int d, int desired_month)
2 {
3     if ( d < 1 || d > days_per_month[desired_month - 1] )
4     {
5         int tempd = d;
6         while ( tempd < 1 || tempd > days_per_month[desired_month - 1])
7         {
8             cout << "Day " << tempd << " is invalid " << endl;
9             cout << "Please enter a day in the range 1 - "
10                << days_per_month[desired_month - 1] << " ";
11             cin >> tempd;
12         }
13         cout << "Valid d of " << tempd << " accepted" << endl;
14         d = tempd;
15     }
16     return d;
17 }
18
19 date::date()
20 {
21     cout << "Welcome to the no arg constructor " << endl;
22     int m = 7, d = 22, y = 1961;
23     month = m;    day = d;    year = y;
24 }
25
26 date::date(int y)
27 {
28     cout << "The one argument constructor has been called " << endl;
29     year = get_year(y);        // pass in the desired y, get a good one back
30     month = 1;                // arbitrarily assign a month
31     day = 1;                  // arbitrarily assign a day
32 }
33
34 date::date(int m, int y)
35 {
36     cout << "The two argument constructor has been called " << endl;
37     year = get_year(y);        // pass the desired y, get a good one back
38     month = get_month(m);      // pass the desired m, get a good one back
39     day = 1;                  // just arbitrarily assign a day
40 }
41
42 date::date(int m, int d, int y)
43 {
44     cout << "The three argument constructor has been called " << endl;
45     year = get_year(y);        // use the function that returns valid year
46     month = get_month(m);      // use function that returns checked month
47     day = get_day(d, month);    // use the error checked month
48     return;
49 }

```

```
1Output From Running Program
2
3Welcome to the no arg constructor
4month is 7 day is 22 year is 1961
5
6The one argument constructor has been called
7month is 1 day is 1 year is 1994
8
9The two argument constructor has been called
10Month -3 is invalid
11Please enter a month in the range 1 -12 Valid m of 5 accepted
12month is 5 day is 1 year is 1994
13
14The three argument constructor has been called
15Year -9 is invalid
16Please enter a year greater than 0 Valid y of 1994 accepted
17Month -3 is invalid
18Please enter a month in the range 1 -12 Month 23 is invalid
19Please enter a month in the range 1 -12 Month -9 is invalid
20Please enter a month in the range 1 -12 Month 24 is invalid
21Please enter a month in the range 1 -12 Valid m of 12 accepted
22Day 121 is invalid
23Please enter a day in the range 1 - 31 Valid d of 23 accepted
24month is 12 day is 23 year is 1994
25
26
```

1// destrct1.cpp

```
2// this program illustrates the destructor
3// you write a destructor when you want to control how memory is deallocated for a class you created
4// Most of the time, the default deallocation is fine
5// However, if your class is pointing to a shared page of memory,
6// there are issues concerning whether the deallocation of this object
7// should cause the deallocation of the shared page or should only the
8// deallocation of the last object of that class type cause the deallocation
9// of the page. There are other issues as well.
10
11#include <iostream.h>
12
13class abc
14{
15    private:
16        int a,b,c;
17    public:
18        abc(); // the constructor function, name same as class
19        ~abc(); // the destructor function notice the ~
20};
21
22// This is the constructor function, its name matches the name of the class
23abc::abc()
24{
25    cout << "The no arg constructor was invoked\n";
26    a = b = c = 1;
27}
28
29// This is the destructor function, its name matches the name of the class and is preceeded
30// by a tilde ~
31abc::~~abc()
32{
33    cout << "The no arg DESTRUCTOR was invoked \n";
34
35    // I'm not doing anything special because I'm not pointing at
36    // anything shared, I will just allow the system to deallocate
37    // the three integers, a,b,c in whatever way it sees fit
38}
39
40main()
41{
42    abc a1; // this will cause the constructor to be called
43
44    // having the program go out of scope will cause the destructor
45    // to be invoked. We VERY RARELY call the destructor functions
46    // we just let them happen when they're supposed to happen, i.e.
47    // when a variable or object goes out of scope
48
49Output From Running Program
50
51The no arg constructor was invoked          constructor called when var created
52The no arg DESTRUCTOR was invoked          destructor called when var goes
53                                           out of scope
```

1// destrct2.cpp

2// this program shows multiple scopes and when things go out of scope

3#include <iostream.h>

4

5class **abc**

6{

7 private:

8 int a,b,c;

9 public:

10 abc(); // the constructor function, name same as class

11 ~abc(); // the destructor function notice the ~

12};

13

14// constructor function, called when instances of abcs are created

15abc::abc()

16{

17 cout << "The no arg constructor was invoked\n";

18 a = b = c = 1;

19}

20

21// destructor function, called when instances of abcs are destroyed, mostly by going out of scope

22abc::~~abc()

23{

24 cout << "The no arg DESTRUCTOR was invoked \n";

25

26 // I'm not doing anything special because I'm not pointing at

27 // anything shared, I will just allow the system to deallocate

28 // the three integers, a,b,c in whatever way it sees fit

29 // maybe in your program, you care about what order they are deleted in or

30 // maybe you want to dump the values to an audit file before destroying them

31 // that's the point of a destructor, you can do things when variables are being destroyed

32}

```

1main()
2{
3    cout << "Before abc a1";
4    abc a1;    // this will cause the constructor to be called
5    cout << "After abc a1\n";
6
7    {
8        cout << "\tA new scope has started\n";
9        cout << "\tBefore abc a2 ";
10       abc a2;
11       cout << "\tAfter abc a2 ";
12   } // a2 will go out of scope here, the no arg destructor will be called
13   cout << "\tThe scope with a2 just exited\n";
14
15   {
16       cout << "\tAnother new scope just started\n";
17       cout << "\tBefore abc a3 ";
18       abc a3;
19       cout << "\tAfter abc a3 ";
20
21       {
22           cout << "\t\tYet another new scope started\n";
23           cout << "\t\tBefore abc a4 ";
24           abc a4;
25           cout << "\t\tAfter abc a4 ";
26       } // at this point, a4 will go out of scope, destructor will be invoked
27       cout << "\t\tInnermost scope ended\n";
28   } // at this point, a3 will go out of scope, destructor will be invoked
29   cout << "\tOther scope ended\n";
30   cout << "Program about to end\n";
31} // at this point, a1 will go out of scope, destructor will be invoked
32
33Output From Running Program
34
35Before abc a1    The no arg constructor was invoked
36After abc a1
37    A new scope has started
38    Before abc a2    The no arg constructor was invoked
39    After abc a2    The no arg DESTRUCTOR was invoked
40    The scope with a2 just exited
41    Another new scope just started
42    Before abc a3    The no arg constructor was invoked
43    After abc a3        Yet another new scope started
44        Before abc a4    The no arg constructor was invoked
45        After abc a4    The no arg DESTRUCTOR was invoked
46        Innermost scope ended
47        The no arg DESTRUCTOR was invoked
48    Other scope ended
49Program about to end
50The no arg DESTRUCTOR was invoked

```

```

1// destruct3.cpp
2// this program illustrates the destructor and arrays
3
4#include <iostream.h>
5
6class abc
7{
8    private:
9        int a,b,c;
10    public:
11        abc();           // the constructor function, name same as class
12        ~abc();          // the destructor function notice the ~
13};
14abc::abc()              // no argument constructor
15{
16    cout << "The no arg constructor was invoked\n";
17    a = b = c = 1;
18}
19abc::~~abc()            // no argument destructor
20{
21    cout << "The no arg DESTRUCTOR was invoked \n";
22}
23
24main()
25{
26    cout << "Before abc a1[5] \n";
27    abc a1[5];           // how many times is constructor called?
28    cout << "After abc a1[5] \n\n";
29
30    {
31        cout << "Before abc a2[3] \n";
32        abc a2[3];
33    } // at this point, a2 goes out of scope, how many times is destructor invoked?
34    cout << "After a2 has gone out of scope\n\n";
35} // at this point, a1 goes out of scope, how many times is destructor invoked?

```

1Output From Running Program

2

3Before abc a1[5]

4The no arg constructor was invoked

5The no arg constructor was invoked

6The no arg constructor was invoked

7The no arg constructor was invoked

8The no arg constructor was invoked

9After abc a1[5]

10

11Before abc a2[3]

12The no arg constructor was invoked

13The no arg constructor was invoked

14The no arg constructor was invoked

15The no arg DESTRUCTOR was invoked

16The no arg DESTRUCTOR was invoked

17The no arg DESTRUCTOR was invoked

18After a2 has gone out of scope

19

20The no arg DESTRUCTOR was invoked

21The no arg DESTRUCTOR was invoked

22The no arg DESTRUCTOR was invoked

23The no arg DESTRUCTOR was invoked

24The no arg DESTRUCTOR was invoked

1// destrct4.cpp

```
2// this program illustrates a practical use of a destructor
3// We will have many instances of a class abc which are all pointing at one character string
4// In the destructor, in this case, we will not delete the memory that is being pointed at
5// We will let the system delete the three integers a,b,c
6// We will let the system delete the integer size_of_string
7// We will let the system delete the char * cptr
8// We will then examine the memory pointed to by cptr to see if it still has the string in it
9
10#include <iostream.h>
11
12char s[] = { "This is the shared string they point at\n" };
13
14class abc
15{
16    private:
17        int a,b,c;
18        int size_of_string;
19        char * cptr;    // will point to shared character string
20    public:
21        abc();           // the constructor function, name same as class
22        ~abc();          // the destructor function notice the ~
23        void print_abc();
24};
25
26abc::abc()
27{
28    cout << "The no arg constructor was invoked\n";
29    a = b = c = 1;
30    cptr = &s[0];
31    size_of_string = sizeof(s);    // get the size stored
32}
33
34abc::~~abc()
35{
36    cout << "The no arg DESTRUCTOR was invoked \n";
37    // At this point I could do something to s if I wanted to
38    // For this application I won't. I will leave it alone
39    // In destrct5.cpp and destrct6.cpp, I will do things to s
40}
41
42void abc::print_abc()
43{
44    cout << "In print_abc values are: \n";
45    cout << a << " " << b << " " << c << endl;
46    cout.write(cptr,size_of_string);
47}
```



```

1main()
2{
3    // create an abc, it will have a pointer to s in it
4    cout << "Before abc a1 s has " << s << endl;
5    abc a1;                                // this will cause the constructor to be called
6    cout << "After abc a1 s has " << s << endl;
7    a1.print_abc();
8
9    {
10       // create another abc, it will also have a pointer to s
11       cout << "Before abc a2 s has " << s << endl;
12       abc a2;                                // this will cause the constructor to be called
13       cout << "After abc a2 s has " << s << endl;
14       a2.print_abc();
15    } // cause a2 to go out of scope, the destructor will be called
16    // a1 still exists and presumably still points at the character string
17
18    cout << "After a2 has gone out of scope, s has " << s << endl;
19    a1.print_abc(); // see if a1 is still okay
20} // at this point, a1 will go out of scope, we still don't do anything to the string s
21    // the string s was just something the instances of abc's were pointing at
22    // the string s was not part of abc instances
23    // so in this case it would make sense to delete the pointer to the string but not the string

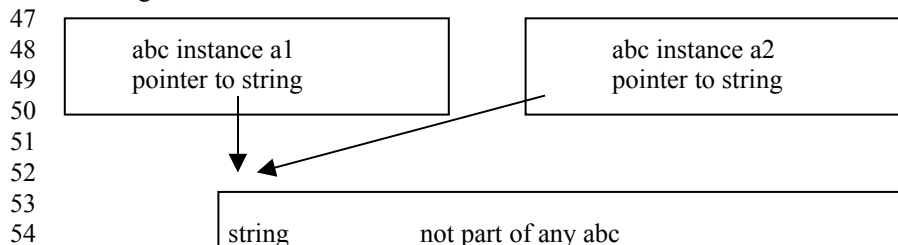
```

25Output From Running Program

```

26
27Before abc a1 s has This is the shared string they point at
28The no arg constructor was invoked
29After abc a1 s has This is the shared string they point at
30
31In print_abc values are:
321 1 1
33This is the shared string they point at
34Before abc a2 s has This is the shared string they point at
35The no arg constructor was invoked
36After abc a2 s has This is the shared string they point at
37
38In print_abc values are:
391 1 1
40This is the shared string they point at
41The no arg DESTRUCTOR was invoked
42After a2 has gone out of scope, s has This is the shared string they point at
43In print_abc values are:
441 1 1
45This is the shared string they point at
46The no arg DESTRUCTOR was invoked

```



1// destruct5.cpp

2// In this version of the destructor program I am going to manipulate the string that the abc
3// instances point at. This may be a dumb thing to do, but the point is who is in control, not whether
4// what you do is smart!!

5#include <iostream.h>

6#include <string.h>

7

8char s[] = { "This is the shared string they point at\n" };

9

10class **abc**

11{

12 private:

13 int a,b,c;

14 char * cptr; // will point to shared character string

15 public:

16 abc(); // the constructor function, name same as class

17 ~abc(); // the destructor function notice the ~

18 void print_abc();

19};

20

21abc::abc()

22{

23 cout << "The no arg constructor was invoked\n";

24 a = b = c = 1;

25 cptr = &s[0];

26}

27

28abc::~~abc()

29{

30 cout << "The no arg DESTRUCTOR was invoked \n";

31 // Now I am going to manipulate the shared string

32 // This may be a stupid thing to do, but that's the point

33 // When you write the destructor, you control what happens when

34 // your objects are deallocated

35 strcpy(cptr,"NEW STRING FROM DESTRUCTOR\n");

36}

37

38void abc::print_abc()

39{

40 cout << "In print_abc values are: \n";

41 cout << a << " " << b << " " << c << endl;

42 cout.write(cptr,sizeof(s));

43}

```

1main()
2{
3    // create an abc, it will have a pointer to s in it
4    cout << "Before abc a1 s has " << s << endl;
5    abc a1;                                // this will cause the constructor to be called
6    cout << "After abc a1 s has " << s << endl;
7    a1.print_abc();
8
9    {
10       // create another abc, it will also have a pointer to s
11       cout << "Before abc a2 s has " << s << endl;
12       abc a2;                                // this will cause the constructor to be called
13       cout << "After abc a2 s has " << s << endl;
14       a2.print_abc();
15    } // cause a2 to go out of scope, this will cause destructor to be invoked
16    // remember, in the destructor, I have decided to manipulate s
17
18    cout << "After a2 has gone out of scope, s has " << s << endl;
19
20    a1.print_abc();                            // see if a1 is still okay
21}
22
23Output From Running Program
24
25Before abc a1 s has This is the shared string they point at
26
27The no arg constructor was invoked
28After abc a1 s has This is the shared string they point at
29
30In print_abc values are:
311 1 1
32This is the shared string they point at
33
34Before abc a2 s has This is the shared string they point at
35
36The no arg constructor was invoked
37After abc a2 s has This is the shared string they point at
38
39In print_abc values are:
401 1 1
41This is the shared string they point at
42
43The no arg DESTRUCTOR was invoked
44After a2 has gone out of scope, s has NEW STRING FROM DESTRUCTOR
45
46In print_abc values are:
471 1 1
48NEW STRING FROM DESTRUCTOR
49ey point at
50
51The no arg DESTRUCTOR was invoked
52

```

notice that a1 points to the start of the string
but it's length field wasn't manipulated
so left over stuff was included in the string

1// destruct6.cpp

```
2// In this program I am going to have a static variable keep track of how many instances are in
3// existence. When the last instance goes out of scope, I am then and only then going to manipulate
4// the string that the instances of abcs are pointing at. This of course begs the question, "What are
5// you going to do if someone creates ANOTHER instance of an abc?" Well... The, um, uh
6// Oh Yeah, the static variable would have the value zero and I could check for that in the constructor
7// and do something to the string area. Whew. Got out of that one.
8
9#include <iostream.h>
10#include <string.h>
11
12char s[] = { "This is the shared string they point at\n" };
13
14class abc
15{
16    private:
17        static int count_of_active_objects;    // static variable
18                                                // used to track how many of this type of object exist
19        int a,b,c;
20        char * cptr;                          // will point to shared character string
21    public:
22        abc();                                // the constructor function, name same as class
23        ~abc();                               // the destructor function notice the ~
24        void print_abc();
25};
26
27abc::abc()
28{
29    cout << "The no arg constructor was invoked\n";
30    a = b = c = 1;
31    cptr = &s[0];
32    count_of_active_objects++;                // add one to the count stored in the static variable
33}
34
35abc::~~abc()
36{
37    cout << "The no arg DESTRUCTOR was invoked \n";
38    // only manipulate if you are the last one alive
39    if ( count_of_active_objects == 1 )
40    {
41        strcpy(cptr,"NEW STRING FROM DESTRUCTOR\n");
42    }
43    else
44    {
45        cout << "I am not last surviving object\n";
46        cout << "I am not going to hurt s \n";
47    }
48    count_of_active_objects--;                // decrement number of living objects
49}
```

```

1 void abc::print_abc() {
2     cout << "In print_abc values are: \n";
3     cout << a << " " << b << " " << c << endl;
4     cout.write(cptr,sizeof(s) );
5 }
6
7 int abc::count_of_active_objects = 0;           // initialize the static variable
8
9 main() {
10    // create an abc, it will have a pointer to s in it
11    cout << "Before abc a1 s has " << s << endl;
12    abc a1;                                       // this will cause the constructor to be called
13    cout << "After abc a1 s has " << s << endl;
14    a1.print_abc();
15    {
16        // create another abc, it will also have a pointer to s
17        cout << "Before abc a2 s has " << s << endl;
18        abc a2; // this will cause the constructor to be called
19        cout << "After abc a2 s has " << s << endl;
20        a2.print_abc();
21    } // cause a2 to go out of scope
22    cout << "After a2 has gone out of scope, s has " << s << endl;
23    a1.print_abc();                             // see if a1 is still okay
24 }
25
26 Output From Running Program
27
28 Before abc a1 s has This is the shared string they point at
29
30 The no arg constructor was invoked
31 After abc a1 s has This is the shared string they point at
32
33 In print_abc values are:
34 1 1
35 This is the shared string they point at
36 Before abc a2 s has This is the shared string they point at
37
38 The no arg constructor was invoked
39 After abc a2 s has This is the shared string they point at
40
41 In print_abc values are:
42 1 1
43 This is the shared string they point at
44 The no arg DESTRUCTOR was invoked
45 I am not last surviving object
46 I am not going to hurt s
47 After a2 has gone out of scope, s has This is the shared string they point at
48
49 In print_abc values are:
50 1 1
51 This is the shared string they point at
52 The no arg DESTRUCTOR was invoked

```

1// destruct7.cpp

```
2// this program also uses a static variable to manipulate the string being pointed at
3// However, along with having instances of abcs pointing at the string, I will also attempt to have
4// non class variables pointing at and using the string. So in this case, maybe the class destructor
5// should have kept it's grubby paws off the string eh??

6
7#include <iostream.h>
8#include <string.h>
9
10char s[] = { "This is the shared string they point at\n" };
11
12class abc
13{
14    private:
15        static int count_of_active_objects; // static variable used to track
16                                           // how many of this type of object exist
17        int a,b,c;
18        char * cptr; // will point to shared character string
19    public:
20        abc(); // the constructor function, name same as class
21        ~abc(); // the destructor function notice the ~
22        void print_abc();
23};
24
25abc::abc()
26{
27    cout << "The no arg constructor was invoked\n";
28    a = b = c = 1;
29    cptr = &s[0];
30    count_of_active_objects++; // add one to the count
31}
32
33abc::~~abc()
34{
35    cout << "The no arg DESTRUCTOR was invoked \n";
36    // only manipulate if you are the last one alive
37    if ( count_of_active_objects == 1 )
38    {
39        strcpy(cptr,"NEW STRING FROM DESTRUCTOR\n");
40    }
41    else
42    {
43        cout << "I am not last surviving object\n";
44        cout << "I am not going to hurt s \n";
45    }
46    count_of_active_objects--; // decrement number of living objects
47}
48void abc::print_abc()
49{
50    cout << "In print_abc values are: \n";
51    cout << a << " " << b << " " << c << endl;
52    cout.write(cptr,sizeof(s) );
53}
```

```

1int abc::count_of_active_objects = 0;    // initialize the static variable
2
3main()
4{
5    {
6        // create an abc, it will have a pointer to s in it
7        cout << "Before abc a1 s has " << s << endl;
8        abc a1;                                // this will cause the constructor to be called
9        cout << "After abc a1 s has " << s << endl;
10       a1.print_abc();
11
12       {
13           // create another abc, it will also have a pointer to s
14           cout << "Before abc a2 s has " << s << endl;
15           abc a2;                                // this will cause the constructor to be called
16           cout << "After abc a2 s has " << s << endl;
17           a2.print_abc();
18       }                                // cause a2 to go out of scope
19       cout << "After a2 has gone out of scope, s has " << s << endl;
20
21       a1.print_abc();                    // see if a1 is still okay
22   }
23   // at this point, a1 and a2 have gone out of scope, there are no abc instances left
24   // so can anyone else use s? Or has the selfish abc class ruined it for everyone?
25   cout << "After a1 has gone out of scope, s has " << s << endl;
26}

```

27Output From Running Program

28Before abc a1 s has This is the shared string they point at

29

30The no arg constructor was invoked

31After abc a1 s has This is the shared string they point at

32In print_abc values are:

331 1 1

34This is the shared string they point at

35Before abc a2 s has This is the shared string they point at

36

37The no arg constructor was invoked

38After abc a2 s has This is the shared string they point at

39

40In print_abc values are:

411 1 1

42This is the shared string they point at

43The no arg DESTRUCTOR was invoked

44I am not last surviving object

45I am not going to hurt s

46After a2 has gone out of scope, s has This is the shared string they point at

47

48In print_abc values are:

491 1 1

50This is the shared string they point at

51The no arg DESTRUCTOR was invoked

52After a1 has gone out of scope, s has NEW STRING FROM DESTRUCTOR

1// ch1p4.cpp

```
2// program to illustrate role of public, protected, private in function
3// visibility. There are two places to check, within member function code
4// and outside of member function code, i.e. in main()
5
6#include <iostream.h>
7#include <stdio.h>
8
9class abc
10{
11    public:
12        void pubf1();
13        void pubf2();
14        abc();
15    protected:
16        void protf1();
17        void protf2();
18    private:
19        void privf1();
20        void privf2();
21};
22
23abc::abc() { cout << "No arg constructor invoked \n"; }
24
25// from inside the member functions of a class you are able to call the
26// public, protected and private member functions of that class
27// PUBLIC FUNCTION
28void abc::pubf1()
29{
30    cout << "In pubf1() \n";
31    this->pubf2(); // try to call a public function, you will succeed
32    this->protf2(); // try to call a protected function, will succeed
33    this->privf2(); // try to call a private function, will succeed
34}
35// PROTECTED FUNCTION
36void abc::protf1()
37{
38    cout << "In protf1() \n";
39    this->pubf2(); // try to call a public function, you will succeed
40    this->protf2(); // try to call a protected function, will succeed
41    this->privf2(); // try to call a private function, will succeed
42}
43// PRIVATE FUNCTION
44void abc::privf1()
45{
46    cout << "In privf1() \n";
47    this->pubf2(); // try to call a public function, will succeed
48    this->protf2(); // try to call a protected function, will succeed
49    this->privf2(); // try to call a private function, will succeed
50}
```



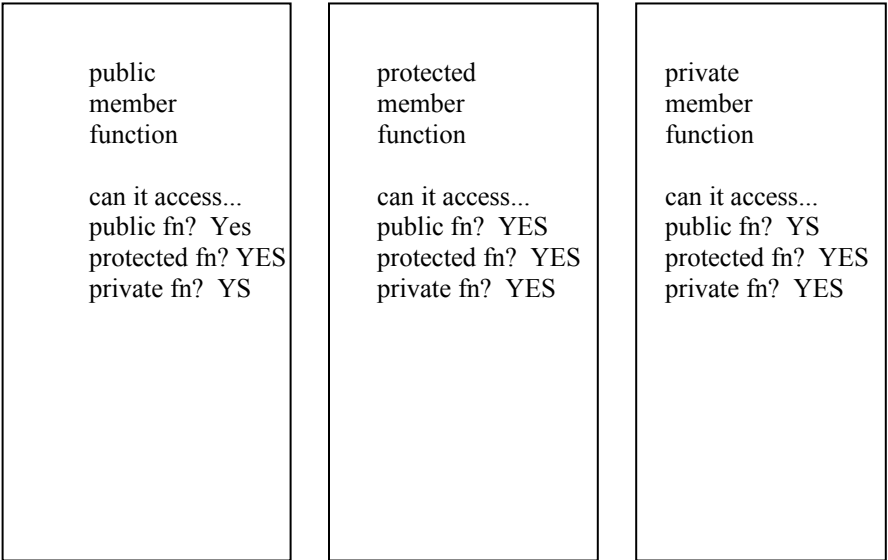
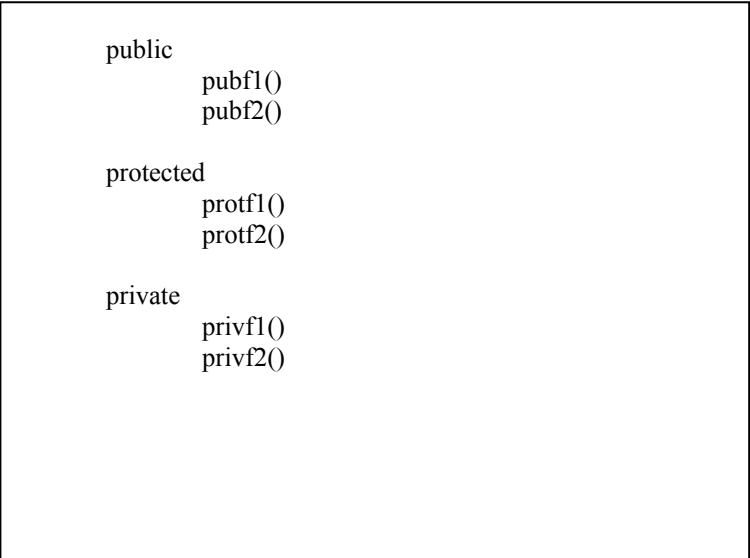
```

1// Public Function
2void abc::pubf2()
3{
4    cout << "IN PUBf2() \n";
5}
6// Protected Function
7void abc::protf2()
8{
9    cout << "IN PROTf2() \n";
10}
11// Private Function
12void abc::privf2()
13{
14    cout << "IN PRIVf2() \n";
15}
16
17// from non member function code, i.e. inside main
18// you MAY CALL the public member functions of a class
19// you MAY NOT CALL the protected or private member functions of a class
20main()
21{
22    abc a1;                // create an instance of an abc
23    a1.pubf1();            // try to call the public function
24    cout << endl << endl; // endl is a constant that == "\n"
25
26    // this line will not compile
27    // if you uncomment it you will see compiler error message
28    // abc::protf1() is not accessible in function main()
29    // a1.protf1();        // try to call the protected function
30
31    // this line will not compile
32    // if you uncomment it you will see compiler error message
33    // abc::privf1() is not accessible in function main()
34    // a1.privf1();        // try to call the private function
35
36    a1.pubf2();            // try to call the other public function
37
38    // this line will not compile
39    // if you uncomment it you will see compiler error message
40    // abc::protf2() is not accessible in function main()
41    // a1.protf2();        // try to call the other protected function
42
43    // this line will not compile
44    // if you uncomment it you will see compiler error message
45    // abc::privf2() is not accessible in function main()
46    // a1.privf2();        // try to call the other private function
47}

```

```
1Output From Running Program
2
3No arg constructor invoked
4In pubf1()
5IN PUBf2()
6IN PROTf2()
7IN PRIVf2()
8
9
10IN PUBf2()
```

1
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51



1// **strct10.cpp**

```
2// In this program, the error checking routines of strctev9.cpp are made
3// PRIVATE MEMBER FUNCTIONS of the class
4// this means that they will be visible only to the designer of the class
5// Since it is the designer of the class who is carefully coding in the
6// error checking properties of the class, it is the designer of the class
7// who needs to be able to call the routines. The user of the date class
8// has no need to know or care that these routines even exist.
9// This reduces the number of subroutines the user of the class needs
10// to concern themselves with. This reduces complexity for the class user
11
12char * months[12] =
13{
14    "January", "February", "March", "April", "May", "June", "July",
15    "August", "September", "October", "November", "December"
16};
17
18int days_per_month[12] = { 31, 28, 31, 30, 31, 30, 31, 31, 30, 31, 30, 31 };
19
20#include <iostream.h>
21#include <stdio.h>
22#include <stdlib.h>
23
24class date
25{
26    public:
27        date();           // no argument constructor
28        date(int);        // one argument constructor
29        date(int,int);     // two argument constructor
30        date(int,int,int); // three argument constructor
31
32        void print_date(); // function to display a date
33
34    private:
35        int month;         // DOMAIN    1 - 12
36        int day;           // DOMAIN    depends on month
37        int year;          // DOMAIN    0 to whatever
38
39        // These are now PRIVATE MEMBER FUNCTIONS
40        int get_year(int); // private member functions
41        int get_month(int); // may be called from member funcs
42        int get_day(int,int); // may not be called from main()
43};
```

```

1main()
2{
3    date d1;                // create a var d1 of type date specifying no args
4    d1.print_date();
5
6    date d2(-4);            // create a var d2 of type date specifying one arg
7    d2.print_date();
8
9    date d3(23,1994);       // create a var d3 of type date specifying two args
10   d3.print_date();
11
12   date d4(3,32,1994);     // create a var d4 of type date specifying three args
13   d4.print_date();
14}
15
16void date::print_date()
17{
18    cout << " month is " << this->month << " day is " << this->day <<
19    " year is " << this->year << endl << endl;
20}
21
22// in the previous program the header was
23// int get_year(int y)
24// the header changes because now the routine is a member function and
25// the complete function name includes the class name
26
27return    class    function    argument
28type      name     name       list
29|         |        |         |
30|         |        |         |
31|         |        |         |
32|         |        |         |
33|         |        |         |
34|         |        |         |
35int date::get_year(int y)
36{
37    if ( y < 0 )
38    {
39        int tempy = y;        // create a local variable
40
41        while ( tempy < 0 )
42        {
43            cout << "Year " << tempy << " is invalid " << endl;
44            cout << "Please enter a year greater than 0 ";
45            cin >> tempy;
46        }
47        cout << "Valid y of " << tempy << " accepted" << endl;
48        y = tempy;
49    }
50    return(y);
51}

```

```

1 int date::get_month(int m)
2 {
3     if ( m < 1 || m > 12 )
4     {
5         int tempm = m;
6         while ( tempm < 1 || tempm > 12 )
7         {
8             cout << "Month " << tempm << " is invalid " << endl;
9             cout << "Please enter a month in the range 1 - 12 ";
10            cin >> tempm;
11        }
12        cout << "Valid m of " << tempm << " accepted" << endl;
13        m = tempm;
14    }
15    return(m);
16}
17
18 int date::get_day(int d, int desired_month)
19 {
20     if ( d < 1 || d > days_per_month[desired_month - 1] )
21     {
22         int tempd = d;
23         while ( tempd < 1 || tempd > days_per_month[desired_month - 1] )
24         {
25             cout << "Day " << tempd << " is invalid " << endl;
26             cout << "Please enter a day in the range 1 - "
27                 << days_per_month[desired_month - 1] << " ";
28             cin >> tempd;
29         }
30         cout << "Valid d of " << tempd << " accepted" << endl;
31         d = tempd;
32     }
33     return d;
34 }

```

```

1// The four constructors are the same as in the last program
2// But now they are going to use the Private Member Functions to do the error checking
3// Instead of external error checking routines
4date::date()
5{
6    cout << "Welcome to the no arg constructor " << endl;
7    int m = 7, d = 22, y = 1961;
8    month = m;    day = d;    year = y;
9}
10
11date::date(int y)
12{
13    cout << "The one argument constructor has been called " << endl;
14    // call the private member function get_year to do the error checking
15    // this constructor is a member function, so it can call the private
16    // member function get_year
17    year = get_year(y);
18    month = 1; // arbitrarily assign a month
19    day = 1;   // arbitrarily assign a day
20}
21
22date::date(int m, int y)
23{
24    cout << "The two argument constructor has been called " << endl;
25    // call the private member functions get_year and get_month from
26    // this public member function date(int,int)
27    year = get_year(y);
28    month = get_month(m);
29    day = 1;
30}
31
32date::date(int m, int d, int y)
33{
34    cout << "The three argument constructor has been called " << endl;
35    // call the private member functions get_year, get_month, get_day
36    // from this public member function date(int,int,int)
37    year = get_year(y);
38    month = get_month(m);
39    day = get_day(d,month);
40    return;
41}
42

```

1Output From Running Program
2
3Welcome to the no arg constructor
4 month is 7 day is 22 year is 1961
5
6The one argument constructor has been called
7Year -4 is invalid
8Please enter a year greater than 0 Valid y of 45 accepted
9 month is 1 day is 1 year is 45
10
11The two argument constructor has been called
12Month 23 is invalid
13Please enter a month in the range 1 - 12 Month -8 is invalid
14Please enter a month in the range 1 - 12 Month 14 is invalid
15Please enter a month in the range 1 - 12 Valid m of 7 accepted
16 month is 7 day is 1 year is 1994
17
18The three argument constructor has been called
19Day 32 is invalid
20Please enter a day in the range 1 - 31 Day 34 is invalid
21Please enter a day in the range 1 - 31 Valid d of 2 accepted
22 month is 3 day is 2 year is 1994
23
24

1// **struct11.cpp**

```
2// Constructors are good for putting INITIAL values into an instance of a date
3// struct variable, but what if I want to CHANGE the values during run-time?
4// We have already seen a routine that could put values into all the fields
5// of an instance of the class
6// What if we want to just put a value into one field at a time?
7
8// Can we do it?
9// Yes.
10
11// We know that we cannot directly address the private data elements of a
12// variable of type date struct from anyplace except a member function,
13// therefore we are going to add member functions to set the data elements.
14// We will add routines to set any individual field or to set all three
15// fields at the same time.
16// The set_year, set_month, and set_day functions will also be able to
17// use the error_checking routines for the struct date data type
18
19char * months[12] =
20{
21    "January", "February", "March", "April", "May", "June", "July",
22    "August", "September", "October", "November", "December"
23};
24
25int days_per_month[12] = { 31, 28, 31, 30, 31, 30, 31, 31, 30, 31, 30, 31 };
26#include <iostream.h>
27#include <stdio.h>
28#include <stdlib.h>
29
30class date
31{
32    public:
33        date();           // no  argument constructor
34        date(int);        // one  argument constructor
35        date(int,int);    // two  argument constructor
36        date(int,int,int); // three argument constructor
37        void print_date(); // function to display a date
38        // These set routines will use the private member functions that do the error checking
39        void set_year(int); // function to change the year value
40        void set_month(int); // function to change the month value
41        void set_day(int);  // function to change the day value
42        void set_all_three(int,int,int); // function to set all three
43    private:
44        int month;          // DOMAIN    1 - 12
45        int day;           // DOMAIN    depends on month
46        int year;          // DOMAIN    0 to whatever
47
48        int get_year(int); // private member functions
49        int get_month(int); // to do the error checking routines
50        int get_day(int,int);
51
52};
53
```

```

1main()
2{
3    date d1;                // create a var d1 of type date specifying no args
4    d1.print_date();
5
6    d1.set_year(1993);      // valid call with valid month
7    d1.print_date();
8
9    d1.set_month(2);        // valid call with valid month
10   d1.print_date();
11
12   d1.set_day(33);          // this will cause error checking to happen
13   d1.print_date();
14
15   d1.set_all_three(12,25,1994); // call to set all three, all three are valid data, error checks will pass
16   d1.print_date();
17
18   d1.set_all_three(-3,89,-2); // call to set all three, three error checks will occur
19   d1.print_date();
20}
21
22void date::print_date()
23{
24    cout << " month is " << this->month << " day is " << this->day <<
25        " year is " << this->year << endl << endl;
26}
27
28
29// The get_year, get_month, get_day functions are the same as the last program
30// The four constructors are the same as the last program

```

```

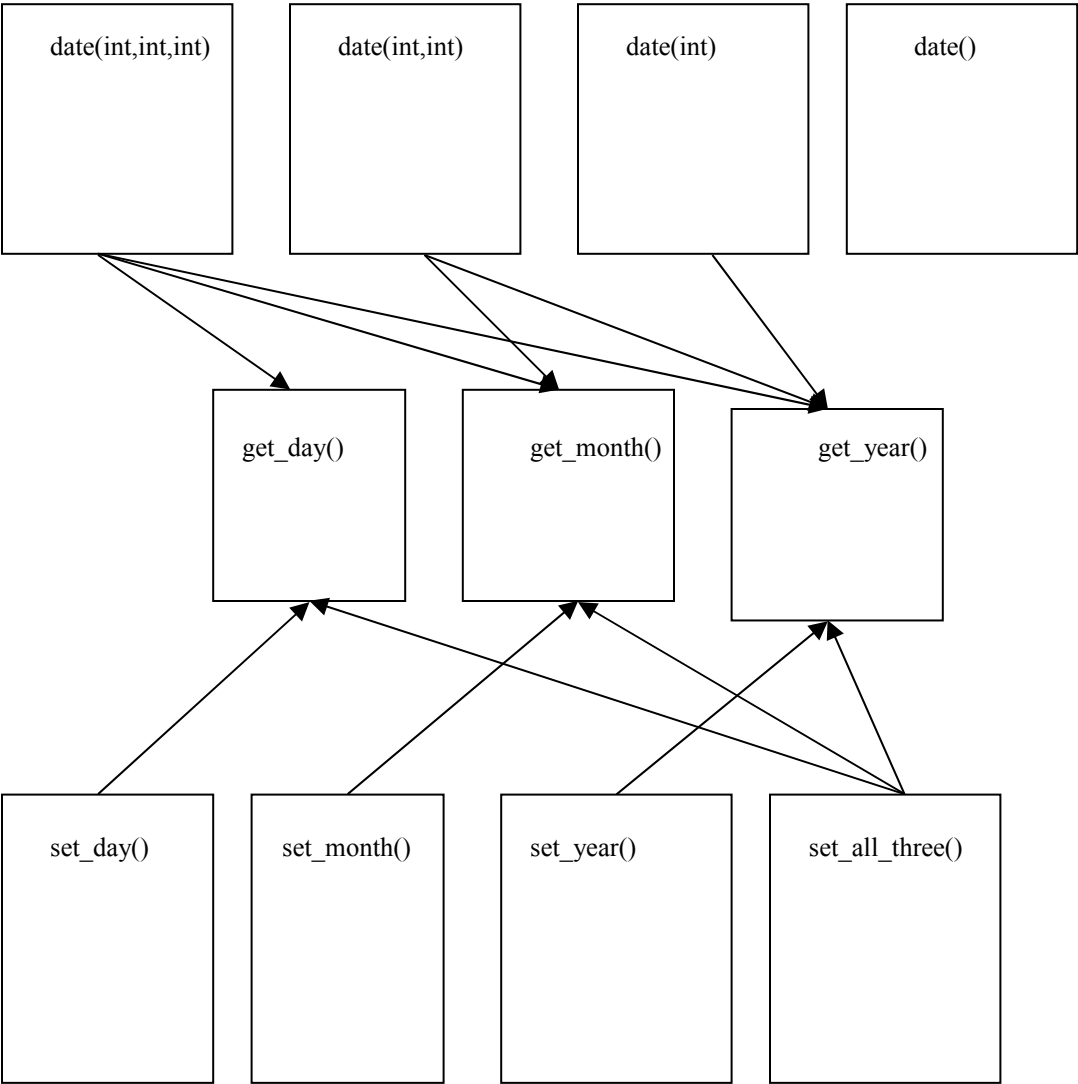
1// all this subroutine has to do is call the get_year function
2 void date::set_year(int y)
3{
4    year = get_year(y);
5    return;
6}
7
8// all this subroutien has to do is call the get_month function
9void date::set_month(int m)
10{
11    month = get_month(m);
12    return;
13}
14
15// all this subroutine has to do is call get_day
16void date::set_day(int d)
17{
18    // we need to already have a valid month to be able to check the day
19    // field of the struct date type variable that was BOUND to this call
20    day = get_day(d,this->month);
21    return;
22}
23
24// this subroutine will call each function in turn
25
26void date::set_all_three(int m, int d, int y )
27{
28    year = get_year(y);
29    month = get_month(m);
30    day = get_day(d,month);
31    return;
32}

```

1Output From Running Programm
2
3 month is 7 day is 22 year is 1961
4
5 month is 7 day is 22 year is 1993
6
7 month is 2 day is 22 year is 1993
8
9Day 33 is invalid
10Please enter a day in the range 1 - 28 Valid d of 23 accepted
11 month is 2 day is 23 year is 1993
12
13 month is 12 day is 25 year is 1994
14
15Year -2 is invalid
16Please enter a year greater than 0 Valid y of 1994 accepted
17Month -3 is invalid
18Please enter a month in the range 1 - 12 Month 89 is invalid
19Please enter a month in the range 1 - 12 Month 0 is invalid
20Please enter a month in the range 1 - 12 Valid m of 7 accepted
21Day 89 is invalid
22Please enter a day in the range 1 - 31 Valid d of 22 accepted
23 month is 7 day is 22 year is 1994
24
25

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49

```
date class  
Private member functions  
    get_year  
    get_month  
    get_day  
Public Member Functions  
    date() date(int) date(int,int) date(int,int,int)  
    set_year(int), set_month(int), set_day(int), set_all_three(int,int,int)
```



1Section 4

2

3This chapter is about user defined data structures and operators.

4C++ allows you to "take over" what operators mean for your defined classes.

5We are used to having to use subroutines to perform operations on our data structures.

6This is bad. It introduces new subroutine names into the programmers name space without providing any
7new functionality. For example, if you make a data structure to model someone's age, you would probably
8want, at some point in time, to be able to add one to their age. In traditional languages you will be forced
9to write a subroutine and use the subroutine by name to add one to your data structure. In C++, you will
10still have to write the subroutine, however you will not have to call it by some ridiculous name like
11add_one_to_age. Instead you will be able to say

12

13 Age a1;

14 ...

15 a1++;

16This will be possible because you will be able to "take over," or overload, the operators for that class.

17Taking over the operators for one class in no way affects how the operators behave for other classes.

18

19You are able to take over:

20 relational operators

21 mathematical operators

22 i/o operators.

23

24Again, to visit our age class, if you wanted to compare two people's ages, in a non C++ language you
25would probably have to make some call like:

26

27 lower = compare_ages(a1,a2);

28

29This is stupid.

30In C++ you will be able to say

31

32 if (a1 < a2)

33

34

or any other relational operator that you have overloaded

because you can take over the operators and redefine what they
mean for your class.

35

36The point of overloading operators is this:

37 You are able to use your classes using the syntax you already know.

38 You don't have to learn a gazillion (gumpism) new names to use a class.

39 The amount of work that is done by the computer at run time is the same,

40 a subroutine is still called and run to do the work,

41 However, the programmer's job was made easier.

1	
2	Section4.doc
3	relops.cpp regular C relational operators and their limitations
4	
5	relops1.cpp relational operations on structures, the serious syntactical limitations
6	
7	relops2.cpp relational operations via operators on C++ classes
8	
9	mathfunc.cpp math operations on structures, the serious syntactical limitations
10	
11	mathops.cpp math operations via operators on C++ classes
12	
13	mathops1.cpp polymorphic math operators
14	
15	ioops.cpp taking over the i/o operators for a class
16	

1// relops.cpp

```
2// C and C++ provide the programmer with a number of operators
3// == + += - -= * *= / /= < <= > >= != and so on
4// these operators only have meaning to pre-defined types
5// the only operator that has any meaning, by default, for user defined types
6// is the = operator
7// If the = operator is applied between two instances of a user defined type
8// then a field wise copy will occur
9// This is a serious limitation of C
10// For example, if you have a data structure like we have been using
11// to model the date, wouldn't it make sense to be able to say
12// if ( d1 < d2 )    or    if ( d1 >= d2 )
13
14// In C, a user is forced to write subroutines like
15// if ( compare_days(d1,d2) )
16// and introduce new names into the programmers name space
17
18// The programmer has already spent the time mastering the C operators
19// Can't we leverage their investment into user defined types? In C++ we can!
20
21// This program is a simple review of C operators
22// It illustrates how simple it is to use the relational operators for a defined type
23
24#include <iostream.h>
25int main()
26{
27    int i = 0, j = 1, k = 1;
28
29    if ( i == j )
30        cout << "i is equivalent to j\n";
31
32    if ( i != j )
33        cout << "i is not equivalent to j\n";
34
35    if ( i < j )
36        cout << "i is less than j\n";
37
38    if ( i <= j )
39        cout << "i is less than or equal to j\n";
40
41    if ( i > j )
42        cout << "i is greater than j\n";
43
44    if ( i >= j )
45        cout << "i is greater than or equal to j\n";
46}
47
48Output From Running Program
49i is not equivalent to j
50i is less than j
51i is less than or equal to j
```


1C Relational Operators

2			
3int	<	int	
4int	<=	int	
5int	>=	int	
6int	>	int	
7int	==	int	
8int	!=	int	
9			
10float	<	float	
11float	<=	float	
12float	>=	float	
13float	>	float	
14float	==	float	
15float	!=	float	
16			
17char	<	char	
18char	<=	char	
19char	>=	char	
20char	>	char	
21char	==	char	
22char	!=	char	
23			
24struct	no relational operators	struct	

1// relops1.cpp

```
2// this program declares a simple time struct with three fields
3// for the sake of listing compactness, error checking is left out
4// this program demonstrates what a user would have to go through
5// to be able to compare two instances of a time struct in the standard six relational ways
6
7#define TRUE 1
8#define FALSE 0
9
10#include <iostream.h>
11
12struct time
13{
14    int h,m,s;           // hours, minutes, seconds
15};
16
17// each of these routines returns TRUE if the condition is met
18// each of these routines returns FALSE if the condition is not met
19// NOTE that each of these functions needs two arguments
20// relational operations are binary operations
21int time_eq(struct time, struct time);
22int time_ne(struct time, struct time);
23int time_gt(struct time, struct time);
24int time_ge(struct time, struct time);
25int time_lt(struct time, struct time);
26int time_le(struct time, struct time);
27
28// to implement the equivalence operation we need to employ the == operator
29// for each field of the struct which is of a pre defined type
30// this routine would have been much more complicated if each field had
31// been itself a user defined type
32// In this case, I have defined equivalent to mean matching on every field
33int time_eq(struct time a, struct time b)
34{
35    if ( (a.h == b.h) && (a.m == b.m) && (a.s == b.s) )
36        return(TRUE);
37    else
38        return(FALSE);
39}
40
41// I have defined not equals to be true if any field doesn't match
42int time_ne(struct time a, struct time b)
43{
44    if ( a.h != b.h )
45        return(TRUE);
46    if ( a.m != b.m )
47        return(TRUE);
48    if ( a.s != b.s )
49        return(TRUE);
50    return(FALSE);
51}
```

```

1// I have defined gt to mean if the clock time of a is later than the clock
2// time of b as measured first on hours, then minutes, then seconds
3int time_gt(struct time a, struct time b)
4{
5    if ( a.h > b.h )
6        return(TRUE);
7    if ( a.h < b.h )
8        return(FALSE);
9
10   // can only get here if a.h == b.h
11   if ( a.m > b.m )
12       return(TRUE);
13   if ( a.m < b.m )
14       return(FALSE);
15
16   // can only get here if a.m == b.m
17   if ( a.s > b.s )
18       return(TRUE);
19
20   return(FALSE);
21}
22
23// return true if time a is later than or equal to time b
24int time_ge(struct time a, struct time b)
25{
26    if ( a.h > b.h )
27        return(TRUE);
28    if ( a.h < b.h )
29        return(FALSE);
30
31    // can only get here if a.h == b.h
32    if ( a.m > b.m )
33        return(TRUE);
34    if ( a.m < b.m )
35        return(FALSE);
36
37    // can only get her if a.m == b.m
38    if ( a.s > b.s )
39        return(TRUE);
40    if ( a.s < b.s )
41        return(FALSE);
42
43    return(TRUE);
44
45}

```

```

1// return TRUE if time a is earlier than time b
2int time_lt(struct time a, struct time b)
3{
4    if ( a.h < b.h )
5        return(TRUE);
6    if ( a.h > b.h )
7        return(FALSE);
8
9    // can only get here if a.h == b.h
10   if ( a.m < b.m )
11       return(TRUE);
12   if ( a.m > b.m )
13       return(FALSE);
14
15   // can only get here if a.m == b.m
16   if ( a.s < b.s )
17       return(TRUE);
18
19   return(FALSE);
20}
21
22// return TRUE if time a is earlier than or equivalent to time b
23int time_le(struct time a, struct time b)
24{
25   if ( a.h < b.h )
26       return(TRUE);
27   if ( a.h > b.h )
28       return(FALSE);
29
30   // can only get here if a.h == b.h
31   if ( a.m < b.m )
32       return(TRUE);
33   if ( a.m > b.m )
34       return(FALSE);
35
36   // can only get her if a.m == b.m
37   if ( a.s < b.s )
38       return(TRUE);
39   if ( a.s > b.s )
40       return(FALSE);
41
42   return(TRUE);
43}

```

```

1 int main()
2 {
3     struct time i = { 1,2,3 };
4     struct time j = { 1,2,4 };
5
6     // instead of being able to say i == j
7     // I have to use the routine time_eq
8     // if ( i == j )
9     if ( time_eq(i,j) )
10        cout << "i is equivalent to j\n";
11
12    // if ( i != j )
13    if ( time_ne(i,j) )
14        cout << "i is not equivalent to j\n";
15
16    // if ( i < j )
17    if ( time_lt(i,j) )
18        cout << "i is less than j\n";
19
20    // if ( i <= j )
21    if ( time_le(i,j) )
22        cout << "i is less than or equal to j\n";
23
24    // if ( i > j )
25    if ( time_gt(i,j) )
26        cout << "i is greater than j\n";
27
28    // if ( i >= j )
29    if ( time_ge(i,j) )
30        cout << "i is greater than or equal to j\n";
31 }
32
33 Output From Running Program
34 i is not equivalent to j
35 i is less than j
36 i is less than or equal to j

```

1 **Functions To Implement Relational Operations For**
2 **User Defined Data Type in C**

3

4data type	function	data type	relational operation implemented
5			
6struct time	time_eq	struct time	(==)
7struct time	time_ne	struct time	(!=)
8struct time	time_gt	struct time	(>)
9struct time	time_ge	struct time	(>=)
10struct time	time_lt	struct time	(<)
11struct time	time_le	struct time	(<=)

12

13

14Wouldn't you rather use the relational operator than have to learn six new function names to compare a
15struct time to a struct time? In C++ you can.

1// relops2.cpp

```
2// this program redeclares a simple time struct with three fields
3// AS A CLASS WHERE THE RELATIONAL OPERATORS HAVE BEEN TAKEN OVER
4// by taking over the relational operators for our defined class
5// we eliminate the six new names for the relational subroutines that
6// the user would have to learn
7// the same amount of work is still done by the executable, meaning that the
8// same six subroutines are called, the point though is the intuitiveness of
9// the interface to the defined class
10
11#define      TRUE      1
12#define      FALSE     0
13
14#include <iostream.h>
15
16// ANY operator functions that we declare, will by default
17// have as the BOUND object, an instance of a class time
18// the BOUND object will always appear to the immediate left of the operator
19class time
20{
21    private:
22        int h,m,s;           // hours, minutes, seconds
23
24    public:
25        time(int,int,int);    // three argument constructor
26
27        // int          is the return type of the operation
28        // operator      is a keyword that identifies which operator we are taking over
29        // ==            is the operator we are taking over
30        // (time)        is the argument that will be on the immediate right
31        //                of the operator we are taking over if it is a binary operator
32        //                by definition a time must be on the immediate left of the operator for the class
33        //                for which the operator is being taken over
34        int operator == (time);
35        int operator != (time);
36        int operator > (time);
37        int operator >= (time);
38        int operator < (time);
39        int operator <= (time);
40};
41
42// when we make a statement like
43// if ( i == j )
44// the subroutine operator == will be invoked
45// i, being on the left of the operator, will be BOUND to the call and will
46// be accessible through the "this" pointer
47// j, being on the right of the operator, will be PASSED as an argument to
48// the subroutine call
```

```

1// each of these routines returns TRUE if the condition is met
2// each of these routines returns FALSE if the condition is not met
3
4// return type          int
5// function name        operator ==
6// class ownership      time
7// argument list        object of type time
8int time::operator == (time a)
9{
10     cout << "The == operator was invoked \n"; // teaching print statement to show subr was called
11     if ( (this->h == a.h) && (this->m == a.m) && (this->s == a.s) )
12         return(TRUE);
13     else
14         return(FALSE);
15}
16
17// I have defined != to be true if any field doesn't match
18int time::operator !=(time b)
19{
20     cout << "The != operator was invoked \n";
21     if ( this->h != b.h )
22         return(TRUE);
23     if ( this->m != b.m )
24         return(TRUE);
25     if ( this->s != b.s )
26         return(TRUE);
27     return(FALSE);
28}
29
30// I have defined > to mean if the clock time of a is later than the clock
31// time of b as measured first on hours, then minutes, then seconds
32int time::operator > (time b)
33{
34     cout << "The > operator was invoked \n";
35     if ( this->h > b.h )
36         return(TRUE);
37     if ( this->h < b.h )
38         return(FALSE);
39
40     // can only get here if a.h == b.h
41     if ( this->m > b.m )
42         return(TRUE);
43     if ( this->m < b.m )
44         return(FALSE);
45
46     // can only get here if a.m == b.m
47     if ( this->s > b.s )
48         return(TRUE);
49
50     return(FALSE);
51}

```



```

1// return true if time a is later than or equal to time b
2int time::operator >= (time b)
3{
4    cout << "The >= operator was invoked \n";
5    if ( this->h > b.h )
6        return(TRUE);
7    if ( this->h < b.h )
8        return(FALSE);
9
10   // can only get here if a.h == b.h
11   if ( this->m > b.m )
12       return(TRUE);
13   if ( this->m < b.m )
14       return(FALSE);
15
16   // can only get her if a.m == b.m
17   if ( this->s > b.s )
18       return(TRUE);
19   if ( this->s < b.s )
20       return(FALSE);
21
22   // only get here if a.h == b.h, a.m == b.m and a.s == b.s
23   return(TRUE);
24}
25
26// return TRUE if time a is earlier than time b
27int time::operator < (time b)
28{
29    cout << "The < operator was invoked \n";
30    if ( this->h < b.h )
31        return(TRUE);
32    if ( this->h > b.h )
33        return(FALSE);
34
35   // can only get here if a.h == b.h
36   if ( this->m < b.m )
37       return(TRUE);
38   if ( this->m > b.m )
39       return(FALSE);
40
41   // can only get here if a.m == b.m
42   if ( this->s < b.s )
43       return(TRUE);
44
45   return(FALSE);
46}

```

```

1// return TRUE if time a is earlier than or equivalent to time b
2int time::operator <= (time b)
3{
4    cout << "The <= operator was called \n";
5    if ( this->h < b.h )
6        return(TRUE);
7    if ( this->h > b.h )
8        return(FALSE);
9
10   // can only get here if a.h == b.h
11   if ( this->m < b.m )
12       return(TRUE);
13   if ( this->m > b.m )
14       return(FALSE);
15
16   // can only get her if a.m == b.m
17   if ( this->s < b.s )
18       return(TRUE);
19   if ( this->s > b.s )
20       return(FALSE);
21
22   return(TRUE);
23}
24
25// three argument constructor
26time::time(int a, int b, int c) : h(a), m(b), s(c)
27{
28}

```

```

1int main()
2{
3    time i(1,2,3);
4    time j(1,2,4);
5
6    // if ( time_eq(i,j) )
7    // now I can use the operator == that the programmer already knows
8    // I am not polluting their name space with a function name like time_eq
9    if ( i == j )
10        cout << "i is equivalent to j\n";
11
12    // if ( time_ne(i,j) )
13    if ( i != j )
14        cout << "i is not equivalent to j\n";
15
16    // if ( time_lt(i,j) )
17    if ( i < j )
18        cout << "i is less than j\n";
19
20    // if ( time_le(i,j) )
21    if ( i <= j )
22        cout << "i is less than or equal to j\n";
23
24    // if ( time_gt(i,j) )
25    if ( i > j )
26        cout << "i is greater than j\n";
27
28    // if ( time_ge(i,j) )
29    if ( i >= j )
30        cout << "i is greater than or equal to j\n";
31}

```

32
33Output From Running Program

```

34
35The == operator was invoked
36The != operator was invoked
37i is not equivalent to j
38
39the < operator was invoked
40i is less than j
41
42The <= operator was invoked
43i is less than or equal to j
44
45The > operator was invoked
46The >= operator was invoked

```

1 Overloading C Relational Operators for User Defined Types in C++

2

3 data type	function	data type	relational operation implemented
4			
5 class time	==	class time	(==)
6 class time	!=	class time	(!=)
7 class time	>	class time	(>)
8 class time	>=	class time	(>=)
9 class time	<	class time	(<)
10 class time	<=	class time	(<=)

11

12 It is important to note that a subroutine is still being called. But, instead of having to use a subroutine name
13 to call it, we can use the six relational operators that we already know.

1// **mathfunc.cpp**

```
2// This program adds additional math oriented features to the time class from the relops
3// programs. This program uses three functions to implement the new math
4// functionality
5
6// As a general rule, when doing math on 2 instances of the same class, an instance of that class
7// should be yielded as the result, and neither of the 2 instances involved in the operation should be
8// affected
9
10// For example, when you type x = i + j you expect x to be of the same type as i and j
11// and you expect i and j to be unaffected
12
13// I want to define what it means to add one time to another
14// To do this for my user defined types I have to write subroutines
15// In C, I have to call the subroutines by name
16// In C++ , in mathops.cpp we will see, that we can overload the math operators to call our subroutines
17
18// For the time class I have now added a day field that will be set to:
19// 1 if adding two times together would roll into the next day
20// 0 if adding two times together would not roll into the next day
21// -1 if subtracting two times would yield a time that is in yesterday
22
23// For the + operation we add a time to a time and return a time
24// For the ++ operation, we add one to the hour field and return a time
25// For the += operation, we add a time to a time and return a time
26
27#define TRUE 1
28#define FALSE 0
29
30#include <iostream.h>
31
32struct time
33{
34    int day; // 1, 0 or -1
35    int h,m,s; // hours, minutes, seconds
36};
37
38
39// return type none
40// function name inc_time
41// argument list struct time called by reference
42// this is implementing the x++ syntax, we expect x to change
43void inc_time( struct time * tptr )
44{
45    tptr->h++;
46    if ( tptr->h >= 24 )
47    {
48        tptr->h -= 24; // roll the hours back by twenty four
49        tptr->day = 1; // indicate that a day rolled over
50    }
51}
```

```

1// return type          none
2// function name        add_time_to_time
3// argument list        two time structs passed by reference
4// this is implementing the x += j syntax
5// we expect x to change, we do not expect j to change
6void add_time_to_time( struct time * tptra, struct time * tptrb)
7{
8    tptra->s += tptrb->s;
9    if ( tptra->s > 60 )
10    {
11        tptra->s -= 60;    // move the seconds field back by 60
12        tptra->m++;        // move the minutes field ahead by one
13    }
14
15    tptra->m += tptrb->m;
16    if ( tptra->m > 60 )
17    {
18        tptra->m -= 60;    // move the minutes field back by 60
19        tptra->h++;        // move the hours field ahead by one
20    }
21
22    tptra->h += tptrb->h;
23    if ( tptra->h >= 24 )
24    {
25        tptra->h -= 24;    // roll the hours back by twenty four
26        tptra->day = 1;    // indicate that a day rolled over
27    }
28}

```

```

1// return type          struct time
2// function name        add_two_times
3// argument list        two struct times passed by reference
4// this is implementing the x = i + j functionality
5// we expect x to change, we don't expect i or j to change
6struct time add_two_times(struct time * tptra, struct time * tptrb )
7{
8    struct time temp;
9    int minute_carry = 0;
10   int hour_carry = 0;
11
12   temp.s = tptra->s + tptrb->s;
13   if ( temp.s > 60 )
14   {
15       temp.s -= 60;           // move the seconds field back by 60
16       minute_carry = 1; // move the minutes field ahead by one
17   }
18
19   temp.m = tptra->m + tptrb->m + minute_carry;
20   if ( temp.m > 60 )
21   {
22       temp.m -= 60;    // move the minutes field back by 60
23       hour_carry = 1;  // move the hours field ahead by one
24   }
25
26   temp.h = tptra->h + tptrb->h + hour_carry;
27   if ( temp.h >= 24 )
28   {
29       temp.h -= 24;    // roll the hours back by twenty four
30       temp.day = 1;    // indicate that a day rolled over
31   }
32   else
33   {
34       temp.day = 0;
35   }
36   return (temp);       // return the bound object
37}
38
39void print_time(struct time a)
40{
41    cout << "The four fields are "
42        << a.day
43        << " "
44        << a.h
45        << " "
46        << a.m
47        << " "
48        << a.s
49        << endl;
50    return;
51}

```

```

1 int main()
2 {
3     struct time i = {0,1,2,3};
4     struct time j = {0,1,2,4};
5     struct time k;
6
7     cout << "i is ";
8     print_time(i);    // print_time is going to do a field by field output
9                       // Question? Could we overload << stay tuned!
10
11    cout << "j is ";
12    print_time(j);
13    cout << endl << endl;
14
15    // To "add one" to a time, we have to use a subroutine like inc_time(), even though
16    // we have the math operator ++ that we are used to using. The problem is that ++ is only
17    // defined for pre-defined types. Not for user defined types. That's why in this program we
18    // need the subroutine inc_time. In the next program, mathops.cpp, we will NOT use inc_time
19    // We will overload ++ and use it instead. The same subroutine will be called to do the exact
20    // same work, however, the usage of the ++ operator will be more rememberable than the
21    // subroutine inc_time
22    inc_time(&i);
23    cout << "i after inc_time(i) is ";
24    print_time(i);
25    cout << endl << endl;
26
27    add_time_to_time(&i,&j);
28    cout << "i after add_time_to_time(&i,&j) is ";
29    print_time(i);
30    cout << "j after add_time_to_time(&i,&j) is ";
31    print_time(j);
32    cout << endl << endl;
33
34    k = add_two_times(&i,&j);
35    cout << "k after k = add_two_times(&i,&j) is ";
36    print_time(k);
37    cout << "i after k = add_two_times(&i,&j) is ";
38    print_time(i);
39    cout << "j after k = add_two_times(&i,&j) is ";
40    print_time(j);
41    cout << endl << endl;
42 }
43 Output From Running Program
44 i is                                The four fields are 0 1 2 3
45 j is                                The four fields are 0 1 2 4
46
47 i after inc_time(i) is               The four fields are 0 2 2 3
48
49 i after add_time_to_time(&i,&j) is    The four fields are 0 3 4 7
50 j after add_time_to_time(&i,&j) is    The four fields are 0 1 2 4
51
52 k after k = add_two_times(&i,&j) is    The four fields are 0 4 6 11
53 i after k = add_two_times(&i,&j) is    The four fields are 0 3 4 7
54 j after k = add_two_times(&i,&j) is    The four fields are 0 1 2 4

```


1C Math Operators For Pre-defined Types

2		
3	integer	+
4		+=
5		++
6		--
7		-
8		-=
9		/
10		/=
11		*
12		*=
13		<<
14		>>
15		%
16		
17	char	+
18		+=
19		++
20		--
21		-
22		-=
23		/
24		/=
25		*
26		*=
27		<<
28		>>
29		%
30		
31	float	+
32		+=
33		-
34		-=
35		/
36		/=
37		*
38		*=
39		
40	struct	=

= is the only arithmetic operator defined for user defined types

1// **mathops.cpp**

```
2// this program adds additional features to the time class from the relops
3// programs. In this program we take over the + += ++ operators
4// FOR THE TIME CLASS ONLY
5// taking over the + or any other operator FOR A CLASS
6// in no way influences what + means for any of the pre defined types
7// or for any other class
8
9// What we are doing is defining what it means to add one time to another
10// Each class designer can define what it means to perform math between
11// instances of the class of which they are are creating
12// For some classes, it doesn't make sense to be able to add two instances
13// of the class together
14// For other classes it does
15// For this example, focus on the mechanism of what I'm doing, not whether
16// my definition of adding two times together makes sense or not
17
18// For the time class I have now added a day field that will be set to:
19// 1 if adding two times together would roll into the next day
20// 0 if adding two times together would not roll into the next day
21// -1 if subtracting two times would yield a time that is in yesterday
22
23// For the + operation we add a time to a time and return a time
24// For the ++ operation, we add one to the hour field and return a time
25// For the += operation, we add a time to a time and return a time
26
27// Note that the ++ operator is unary, there will be a BOUND object
28// but no argument object
29// the += operator is binary, there will be a BOUND object and an argument
30// the BOUND object will be on the left of the operator
31// the argument will be on the right of the operator
32// the + operator is binary, there will be a BOUND object and an argument
33// the BOUND object will be on the left of the operator
34// the argument will be on the right of the operator
35
36// Note the difference in what is returned for the + ++ and += operations
37// The ++ operation affects the BOUND object
38// The += operation affects the BOUND object but not the argument object
39// The + operation affects neither the BOUND object nor the argument object
```

```

1#define      TRUE      1
2#define      FALSE     0
3
4#include <iostream.h>
5
6class time
7{
8    private:
9        int day;          // 1, 0 or -1
10       int h,m,s;        // hours, minutes, seconds
11
12    public:
13        time(int,int,int);    // three argument constructor
14        time();              // no argument constructor
15        time operator ++ ();    // overload the mathematics operators
16        time operator += (time);
17        time operator + (time);
18        void print_time();
19};
20
21
22// return type      time
23// function name     operator ++
24// class ownership   time
25// argument list     none
26time time::operator ++ ()
27{
28    cout << "The ++ operator was invoked \n";
29    this->h++;
30    if ( this->h >= 24 )
31    {
32        this->h -= 24;    // roll the hours back by twenty four
33        this->day = 1;    // indicate that a day rolled over
34    }
35    return(*this);      // return the bound object
36}

```

```

1// return type           time
2// function name         operator +=
3// class ownership       time
4// argument list         an instance of a time class object
5time time::operator += (time b)
6{
7    cout << "The += operator was invoked \n";
8
9    this->s += b.s;
10   if ( this->s > 60 )
11   {
12       this->s -= 60;    // move the seconds field back by 60
13       this->m++;        // move the minutes field ahead by one
14   }
15
16   this->m += b.m;
17   if ( this->m > 60 )
18   {
19       this->m -= 60;    // move the minutes field back by 60
20       this->h++;        // move the hours field ahead by one
21   }
22
23   this->h += b.h;
24   if ( this->h >= 24 )
25   {
26       h -= 24;         // roll the hours back by twenty four
27       day = 1;         // indicate that a day rolled over
28   }
29   return (*this);      // return the bound object
30}

```

```

1// return type          time
2// function name        operator +
3// class ownership      time
4// argument list        an instance of a time class object
5time time::operator + (time b)
6{
7    cout << "The + operator was invoked \n";
8
9    int hour_carry = 0;
10   int minute_carry = 0;
11
12   time temp;          // can't destroy the BOUND object or the invoking object
13                       // When you say i = j + k you expect i to change
14                       // you don't expect j or k to change
15
16   temp.s = this->s + b.s;
17   if ( temp.s > 60 )
18   {
19       temp.s -= 60;          // move the seconds field back by 60
20       minute_carry = 1; // move the minutes field ahead by one
21   }
22
23   temp.m = this->m + b.m + minute_carry;
24   if ( temp.m > 60 )
25   {
26       temp.m -= 60;          // move the minutes field back by 60
27       hour_carry = 1;        // move the hours field ahead by one
28   }
29
30   emp.h = this->h + b.h + hour_carry;
31   if ( temp.h >= 24 )
32
33       temp.h -= 24;          // roll the hours back by twenty four
34       temp.day = 1;          // indicate that a day rolled over
35   }
36   return (temp);           // return the newly created object
37}
38
39void time::print_time() {
40    cout    << "The four fields are "
41           << day
42           << " "
43           << h
44           << " "
45           << m
46           << " "
47           << s
48           << endl;
49    return;
50}
51// three argument constructor
52time::time(int a, int b, int c) : h(a), m(b), s(c), day(0)
53{
54}

```

```

1 time::time() : h(0), m(0), s(0), day(0)
2 {
3 }
4
5 int main(){
6     time i(1,2,3);    time j(1,2,4);    time k;
7
8     cout << "i is ";    i.print_time();
9
10    cout << "j is ";    j.print_time();
11    cout << endl << endl;
12
13    // increment i using the mathematics operator
14    // You don't have to call some function like increment_time(i)
15    i++;
16    cout << "i after i++ is ";
17    i.print_time();
18    cout << endl << endl;
19
20    // don't have to call some function like add_time_to_time(&i,&j);
21    i += j;
22    cout << "i after i += j is ";
23    i.print_time();
24    cout << "j after i += j is ";
25    j.print_time();
26    cout << endl << endl;
27
28    // don't have to call some function like k = add_two_times(&i,&j)
29    k = i + j;
30    cout << "k after k = i + j is ";
31    k.print_time();
32    cout << "i after k = i + j is ";
33    i.print_time();
34    cout << "j after k = i + j is ";
35    j.print_time();
36    cout << endl << endl;
37}

```

38 Output From Running Program

```

39
40 i is The four fields are 0 1 2 3
41 j is The four fields are 0 1 2 4
42
43 The ++ operator was invoked
44 i after i++ is The four fields are 0 2 2 3
45
46 The += operator was invoked
47 i after i += j is The four fields are 0 3 4 7
48 j after i += j is The four fields are 0 1 2 4
49
50 The + operator was invoked
51 k after k = i + j is The four fields are 0 4 6 11
52 i after k = i + j is The four fields are 0 3 4 7
53 j after k = i + j is The four fields are 0 1 2 4

```

C++ Taking Over Mathematics Operators

```
1
2
3Take over    ++          increment this object by some known amount defined to be "one"
4              this object expected to change
5              x++         x changes
6              x stays the same type
7
8Take over    +=          update this object by "adding" another instance of the same type
9              expect this object to change
10             x += y      x changes, y doesn't
11             y of same type as x
12
13Take over    +           create a new object by "adding" two objects of the same type as the
14              desired yielded object
15              expect new object to change, don't expect existing instances to change
16
17             x = y + zx changes, y doesn't, z doesn't
18             y and z of same type as x
19
20BUT: What If the thing(s) being added to your class aren't of the same type??
21Could we do
22
23Take over    +=          update this object by "adding" some other type instance to it?
24              expect this object to change
25             x += ABC    x of type xyz
26                         ABC of type ABC
27                         x changed but remains of type xyz
28
29             CAN WE DO THIS?
30             Yes!! See mathops1.cpp
31
```

1// mathops1.cpp

```
2
3// In this program we polymorphise the + and += operators
4// Previously we had defined what it meant to add a time to a time
5// Now, additionally, we are going to define what it means to add an int to a time
6// We are going to have a destructive add += time += int
7// We are going to have a non_destructive add + time = time + int
8
9#define TRUE 1
10#define FALSE 0
11
12#include <iostream.h>
13
14class time
15{
16    private:
17        int day; // 1, 0 or -1
18        int h,m,s; // hours, minutes, seconds
19
20    public:
21        time(int,int,int); // three argument constructor
22        time(); // no argument constructor
23
24        // Math operators for times and times
25        time operator ++ ();
26        time operator += (time); // add all the fields to each other
27        time operator + (time);
28
29        // Math operators for times and ints
30        time operator += (int); // add to the hours field
31        time operator + (int); // add to the hours field
32        void print_time();
33};
34
35
36// return type time
37// function name operator ++
38// class ownership time
39// argument list none
40time time::operator ++ ()
41{
42    cout << "The time++ operator was invoked \n";
43    this->h++;
44    if ( this->h >= 24 )
45    {
46        this->h -= 24; // roll the hours back by twenty four
47        this->day = 1; // indicate that a day rolled over
48    }
49    return(*this); // return the bound object
50}
```



```

1// return type          time
2// function name        operator +=
3// class ownership      time
4// argument list        an instance of a time class object
5time time::operator += (time b)
6{
7    cout << "The time += time operator was invoked \n";
8
9    this->s += b.s;
10   if ( this->s > 60 )
11   {
12       this->s -= 60;           // move the seconds field back by 60
13       this->m++;              // move the minutes field ahead by one
14   }
15
16   this->m += b.m;
17   if ( this->m > 60 )
18   {
19       this->m -= 60;           // move the minutes field back by 60
20       this->h++;              // move the hours field ahead by one
21   }
22
23   this->h += b.h;
24   if ( this->h >= 24 )
25   {
26       h -= 24;               // roll the hours back by twenty four
27       day = 1;               // indicate that a day rolled over
28   }
29   return (*this);           // return the bound object
30}
31

```

```

1// return type          time
2// function name        operator +
3// class ownership      time
4// argument list        an instance of a time class object
5time time::operator + (time b)
6{
7    cout << "The time + time operator was invoked \n";
8    int    minute_carry = 0;
9    int    hour_carry = 0;
10   time temp;
11   temp.s = this->s + b.s;
12
13   if ( temp.s > 60 )
14   {
15       temp.s -= 60;           // move the seconds field back by 60
16       minute_carry = 1; // move the minutes field ahead by one
17   }
18
19   temp.m = this->m + b.m + minute_carry;
20   if ( temp.m > 60 )
21   {
22       temp.m -= 60;           // move the minutes field back by 60
23       hour_carry = 1;         // move the hours  field ahead by one
24   }
25
26   temp.h = this->h + b.h;
27   if ( temp.h >= 24 )
28   {
29       temp.h -= 24;           // roll the hours back by twenty four
30       temp.day = 1;           // indicate that a day rolled over
31   }
32   return (temp);              // return the newly created object
33}

```

```

1// THIS IS THE START OF THE POLYMORPHISED FUNCTIONS
2// WE ARE NOW TAKING OVER += and + for a time on the left and an int on the right
3// These are only taken over for this class
4// += and + are not affected for any other class
5// By convention, we expect an object back of the type that is on the left of the operator
6// return type           time
7// function name         operator +=
8// class ownership       time
9// argument list         one integer
10time time::operator += (int b)
11{
12    cout << "The time += int operator was invoked \n";
13
14    this->h += b;
15    if ( this->h >= 24 )
16    {
17        h -= 24;           // roll the hours back by twenty four
18        day = 1;          // indicate that a day rolled over
19    }
20    return (*this);        // return the bound object
21}
22
23// return type           time
24// function name         operator +
25// class ownership       time
26// argument list         an int
27time time::operator + (int b)
28{
29    cout << "The time = time + int operator was invoked \n";
30
31    time temp;
32
33    temp.h = this->h + b;
34    if ( temp.h >= 24 )
35    {
36        temp.h -= 24;      // roll the hours back by twenty four
37        temp.day = 1;      // indicate that a day rolled over
38    }
39    return (temp);         // return the newly created object
40}
41
42void time::print_time()    {
43    cout << "The four fields are "
44        << day
45        << " "
46        << h
47        << " "
48        << m
49        << " "
50        << s
51        << endl;
52    return;
53}

```

```

1// three argument constructor
2time::time(int a, int b, int c) : h(a), m(b), s(c), day(0) { }
3time::time() : h(0), m(0), s(0), day(0) { }
4
5int main()
6{
7    time i(1,2,3); time j(1,2,4); time k;
8
9    cout << "i is ";
10   i.print_time();
11
12   cout << "j is ";
13   j.print_time();
14   cout << endl << endl;
15
16   // PROVE THAT THE OLD WAY STILL WORKS
17   // increment i using the mathematics operator
18   // You don't have to call some function like increment_time(i)
19   i++;
20   cout << "i after i++ is ";
21   i.print_time();
22   cout << endl << endl;
23
24   // don't have to call some function like add_time_to_time(&i,&j);
25   i += j;
26   cout << "i after i += j is ";
27   i.print_time();
28   cout << "j after i += j is ";
29   j.print_time();
30   cout << endl << endl;
31
32   // don't have to call some function like k = add_two_times(&i,&j)
33   k = i + j;
34   cout << "k after k = i + j is ";
35   k.print_time();
36   cout << "i after k = i + j is ";
37   i.print_time();
38   cout << "j after k = i + j is ";
39   j.print_time();
40   cout << endl << endl;
41
42   // SHOW WHAT THE NEW WAY DOES
43   // Now I am going to exercise the new polymorphic features
44   i += 7;
45   cout << "i after i += 7 is ";
46   i.print_time();
47
48   k = i + 4;
49   cout << "k after k = i + 4 is ";
50   k.print_time();
51   cout << "i after k = i + 4 is ";
52   i.print_time();
53}

```

1Output From Running The Program
2
3i is The four fields are 0 1 2 3
4j is The four fields are 0 1 2 4
5
6The **time++** operator was invoked
7i after i++ is The four fields are 0 2 2 3
8
9The **time += time** operator was invoked
10i after i += j is The four fields are 0 3 4 7
11j after i += j is The four fields are 0 1 2 4
12
13The **time = time + time** operator was invoked
14k after k = i + j is The four fields are 0 4 6 11
15i after k = i + j is The four fields are 0 3 4 7
16j after k = i + j is The four fields are 0 1 2 4
17
18
19The **time += int** operator was invoked
20i after i += 7 is The four fields are 0 10 4 7
21
22The **time = time + int** operator was invoked
23k after k = i + 4 is The four fields are 0 14 0 0
24i after k = i + 4 is The four fields are 0 10 4 7
25

1// ioops.cpp

```
2// this program shows how the function print_time can be removed
3// Just like we can take over the relational operators and arithmetic operators
4// We can take over the << operator for any class that we define
5// Again, the same amount of work gets done as when we had to call print_time
6// But the interface is consistent with what the user of the class already
7// applies to pre defined variables and other classes that use this mechanism
8
9// taking over the << operator for this class does not affect the << operator for any other class
10// or any pre-defined or user defined class
11
12// this program introduces two new concepts
13// FRIEND functions
14// REFERENCES
15// If you are unfamiliar with FRIEND functions or REFERENCES
16// There are other examples programs in this book which illustrate how these concepts work
17
18// For the evolutionary flow of taking over relational operators,
19// then mathematics operators then io operators, I have chosen to cover
20// friend functions and references next. It was a real chicken and egg
21// problem. At least showing them in use provides justification for learning
22// them!
23
24#include <iostream.h>
25
26class time
27{
28    private:
29        int day;           // 1, 0 or -1
30        int h,m,s;         // hours, minutes, seconds
31
32    public:
33        time(int,int,int); // three argument constructor
34        time();           // no argument constructor
35
36        // return a reference to an output stream object
37        // take over the << operator
38        // An instance of a time class object must be immediately
39        // to the right of the << operator
40        // An instance of an ostream object must be immediately to the left of the << operator
41        // Called via a call like    cout << t1;
42        // friend says that the function is not a member of the class but may still access the
43    private
44        // data of the instances of the class
45        friend ostream& operator << (ostream&,time);
46};
47
```

```

1// return type          ostream&
2// function name        operator <<
3// class ownershipnone, it is a friend function of two classes
4// argument list        an instance of a time class object
5ostream & operator << (ostream & os, time a)
6{
7    // no variable this is available in a friend function
8    // all addresses need to be passed as arguments
9
10   os << "The ostream << time operator was invoked \n";
11
12   os << "The four fields are "
13   << a.day // this << is between an ostream on the left and an int on the right
14   << " "
15   << a.h // this << is between an ostream on the left and an int on the right
16   << " "
17   << a.m // this << is between an ostream on the left and an int on the right
18   << " "
19   << a.s
20   << endl;
21
22   return(os);
23}
24
25// constructors
26time::time(int a, int b, int c) : h(a), m(b), s(c), day(0) {}
27time::time() : h(0), m(0), s(0), day(0) {}
28
29int main()
30{
31   time i(1,2,3);   time j(1,2,4);   time k;
32
33   cout << "i is \n";
34   cout << i; // don't call print_time, use the << operator instead
35              // the same amount of, and in fact the EXACT same work gets done
36              // the difference is that the programmers already know <<
37              // the programmers don't already know print_time
38              // going with the overloaded operator, they don't need to learn any new
39              // function calls to use your class!!!
40   cout << endl << endl;
41
42   cout << "j is \n";
43   cout << j; // taking over the << for an ostream on the left and a time on the right
44   cout << endl << endl; // does not affect any other calls to <<
45
46   cout << "k is \n"; // this is a call to << with an ostream on the left
47                      //and a string on the right
48   cout << k; // it is unaffected by our taking over for an ostream on the left and
49   cout << endl << endl; // a time on the right
50}

```

1Output From Running Program
2i is
3The ostream << time operator was invoked
4The four fields are 0 1 2 3
5
6j is
7The ostream << time operator was invoked
8The four fields are 0 1 2 4
9
10k is
11The ostream << time operator was invoked
12The four fields are 0 0 0 0

1Section 5

2

3This section is about casting.

4If you are any kind of C programmer you know how casting works.

5You are able to cast from ints to floats and floats to doubles and so on.

6But, in C, if you have a user defined data structure and you want to convert it into some other type of user

7defined data structure or even into one of the pre-defined data types, guess what? You have to write a

8subroutine to do the conversion and then use that subroutine by name. In C++ you will still have to write

9the subroutine to do the conversion, however, you won't have to use the subroutine by name, you will be

10able to invoke it using the same casting syntax that you are already familiar with. This has great value to

11the programmer because we are not polluting their mind with the names of subroutines. We are making use

12of the casting syntax they already know and love (hate?)

13

14The point of creating and overloading casting operators is this:

15 You are able to use your classes using the syntax you already know.

16 You don't have to learn a gazillion (gumpism) new names to use a class.

17 The amount of work that is done by the computer at run time is the same,

18 a subroutine is still called and run to do the work,

19 However, the programmer's job was made easier.

20

21Any time that you can make the programmer's job easier, you are doing something good.

22We want the programmers to focus on the problem to be solved and not on the syntax required to do that.

23

24This section will show you how to provide casting operations between:

25 a user defined class and a pre-defined type using a traditional function

26 a user defined class and a pre defined type using casting operator

27 a pre defined type and a class using a constructor

28

29 a user defined class and the same user defined class

30 a user defined class and a regular C structure

31 a regular C structure and a user defined class

32

33 a user defined class and a different user defined class where no inheritance relationship exists

34 a user defined class and a different user defined class where an inheritance relationship does

35 exist

36

37castfunc.cpp casting a class into a pre-defined type using functions

38

39castops.cpp casting a class into a pre-defined type using casting syntax

40

41castcons.cpp casting pre-defined types to classes using constructors

42

43castcopy.cpp building one instance of a class using another instance of the same class

44

45cls2stct.cpp casting a class instance into a struct instance

46

47stct2cls.cpp casting a struct instance into a class instance

48

49cls2cls1.cpp casting from one class to another class where no inheritance exists

50

51cls2cls2.cpp casting from one class to another where inheritance exists

```

1// castfunc.cpp
2
3#include <iostream.h>
4
5// This program shows how a C programmer would write subroutines
6// to change an instance of a class time into the pre defined data
7// types. These conversions, called casting, may or may not make sense
8// depending on your point of view. What is important, is that the mechanism
9// be explained so that if you wanted to do a conversion like this, you could define what it meant
10class time
11{
12    private:
13        int h,m,s;           // hours, minutes, seconds
14
15    public:
16        time(int,int,int);    // three argument constructor
17        void show_time();     // show what time it is
18
19        // int is the return type of the operation
20        // operator is a keyword that identifies which operator we are taking over
21        // int is the operator we are taking over
22        // (time) is the argument that will be on the immediate right
23        // of the operator we are taking over if it is a binary operator
24        int time_to_int ();    // how to turn a time into an int
25
26        // these are inconvenient to use. If we are going to have conversion routines, we may as
27        // well make them convenient to use. We already have a casting syntax that we are familiar with
28        // i.e. to turn a float into an int we would use      i = (int) f;
29        // so why don't we have casting routines for user-defined types?
30        // the simple answer is that the compiler cannot anticipate what your user defined type will
31        // have as fields and how you want to turn those fields into an int or float or other type
32        // However, the compiler can anticipate our desire to do conversions, therefore we are provided
33        // with a casting syntax like i = (int) f
34        // and the (int) will be an operator. In C++ we can overload this operator just like we have
35        // overloaded the relational and mathematical operators. In the next program, castops.cpp
36        // we do this and therefore don't need routines like time_to_float and time_to_char
37        float time_to_float (); // how to turn a time into a float
38        char time_to_char ();  // how to turn a time into a char
39};
40
41void time::show_time()
42{
43    cout << "h is " << h << endl;
44    cout << "m is " << m << endl;
45    cout << "s is " << s << endl << endl;
46}

```

1	return	class	function	argument
2	type	membership	name	list
3				
4				
5				
6				
7	↓	↓	↓	↓
8	int time:: time_to_int ()			
9	{			
10	cout << "time_to_int was called \n";			
11	return (this->h); // return the integer hour			
12	// you could have done whatever you wanted here			
13	}			
14				
15	float time:: time_to_float ()			
16	{			
17	cout << "The time_to_float routine was called \n";			
18				
19	// I have created some silly conversion from time to float			
20	// you could probably come up with one that made sense			
21	// whoever writes the cast controls what happens			
22	return ((float) (this->h + this->m + this->s));			
23	}			
24				
25	char time:: time_to_char ()			
26	{			
27	cout << "The time_to_char function was called \n";			
28	return ('a'); // obviously you would do something more sophisticated			
29	// than just return the letter a. The point is, that whatever happens, you are in			
30	// control of the conversion from class to defined type			
31	}			
32				
33	// three argument constructor			
34	time::time(int a, int b, int c) : h(a), m(b), s(c)			
35	{			
36	}			

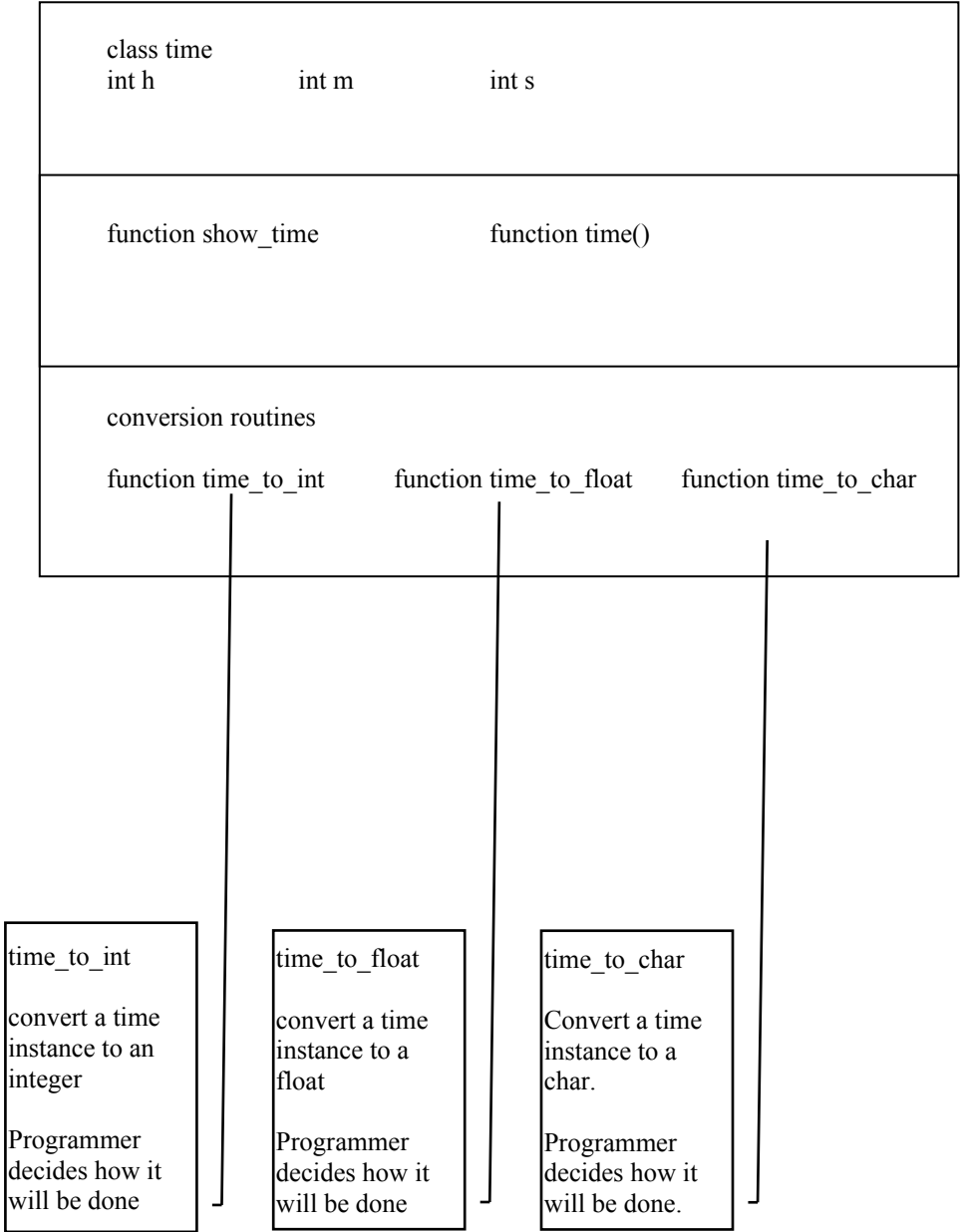
```

1 int main()
2 {
3     time t(1,2,3);
4
5     int i = 0;
6     float f = 0.0;
7     char c = 'C';
8
9     cout << "Before casting i is " << i << endl;
10    cout << "Before casting to int t is ";
11    t.show_time();
12    i = t.time_to_int();
13    cout << "After casting i is " << i << endl;
14    cout << "After casting to int t is ";
15    t.show_time();
16
17    cout << "Before casting f is " << f << endl;
18    cout << "Before casting to float t is ";
19    t.show_time();
20    f = t.time_to_float();
21    cout << "After casting f is " << f << endl;
22    cout << "After casting to float t is ";
23    t.show_time();
24
25    cout << "Before casting c is " << c << endl;
26    cout << "Before casting to char t is ";
27    t.show_time();
28    c = t.time_to_char();
29    cout << "After casting c is " << c << endl;
30    cout << "After casting to char t is ";
31    t.show_time();
32 }

```

1Output From Running Program
2
3Before casting i is 0
4Before casting to int t is h is 1
5m is 2
6s is 3
7
8time_to_int was called
9After casting i is 1
10After casting to int t is h is 1
11m is 2
12s is 3
13
14Before casting f is 0
15Before casting to float t is h is 1
16m is 2
17s is 3
18
19The time_to_float routine was called
20After casting f is 6
21After casting to float t is h is 1
22m is 2
23s is 3
24
25Before casting c is C
26Before casting to char t is h is 1
27m is 2
28s is 3
29
30The time_to_char function was called
31After casting c is a
32After casting to char t is h is 1
33m is 2
34s is 3

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```

1// castops.cpp
2
3#include <iostream.h>
4
5// this program improves castfunc.cpp by using the C++ casting syntax
6// it removes from the programmer the onerous task of learning the names
7// of the conversion routines
8// instead it provides the programmer with the standard casting operators
9// that they are used to using to cast other things to ints, floats chars
10
11// If we are going to allow conversions from one type to another,
12// We may as well make the syntax convenient and straight forward
13
14// C provides the casting syntax i = (int) f + (int) g;
15// C++ extends the casting syntax to user defined types, structs and classes
16
17class time
18{
19    private:
20        int h,m,s;           // hours, minutes, seconds
21
22    public:
23        time(int,int,int);    // three argument constructor
24        void show_time();     // show what time it is
25
26        // int is the return type of the operation
27        // operator is a keyword that identifies which operator we are taking over
28        // int is the operator we are taking over
29        // (time) is the argument that will be on the immediate right
30        // of the operator we are taking over if it is a binary operator
31        operator int ();           // how to turn a time into an int
32        operator float ();       // how to turn a time into a float
33        operator char ();        // how to turn a time into a char
34};
35
36void time::show_time()
37{
38    cout << "h is " << h << endl;
39    cout << "m is " << m << endl;
40    cout << "s is " << s << endl << endl;
41}

```

1Note that the return type is not specified
 2If you are going to provide a casting operator for a class to a type
 3The return type will match the name of the operator
 4In this case the operator is operator int
 5Therefore the return type will be int

6				
7	return	class	function argument	
8	type	membership	name	list
9				
10				
11				
12				
13				

```

14time::operator int ( )
15{
16    cout << "The (int) operator was invoked \n";
17    return ( this->h );           // return the integer hour
18    // you could have done whatever you wanted here
19}
20
21
22float time::operator float( )
23{
24    cout << "The float operator was invoked \n";
25
26    // I have created some silly conversion from time to float
27    // you could probably come up with one that made sense
28    // whoever writes the cast controls what happens
29    return ( (float) (this->h + this->m + this->s) );
30}
31
32char time::operator char ( )
33{
34    cout << "The char operator was invoked \n";
35    return ( 'a' );
36}
37
38// three argument constructor
39time::time(int a, int b, int c) : h(a), m(b), s(c)
40{
41}

```



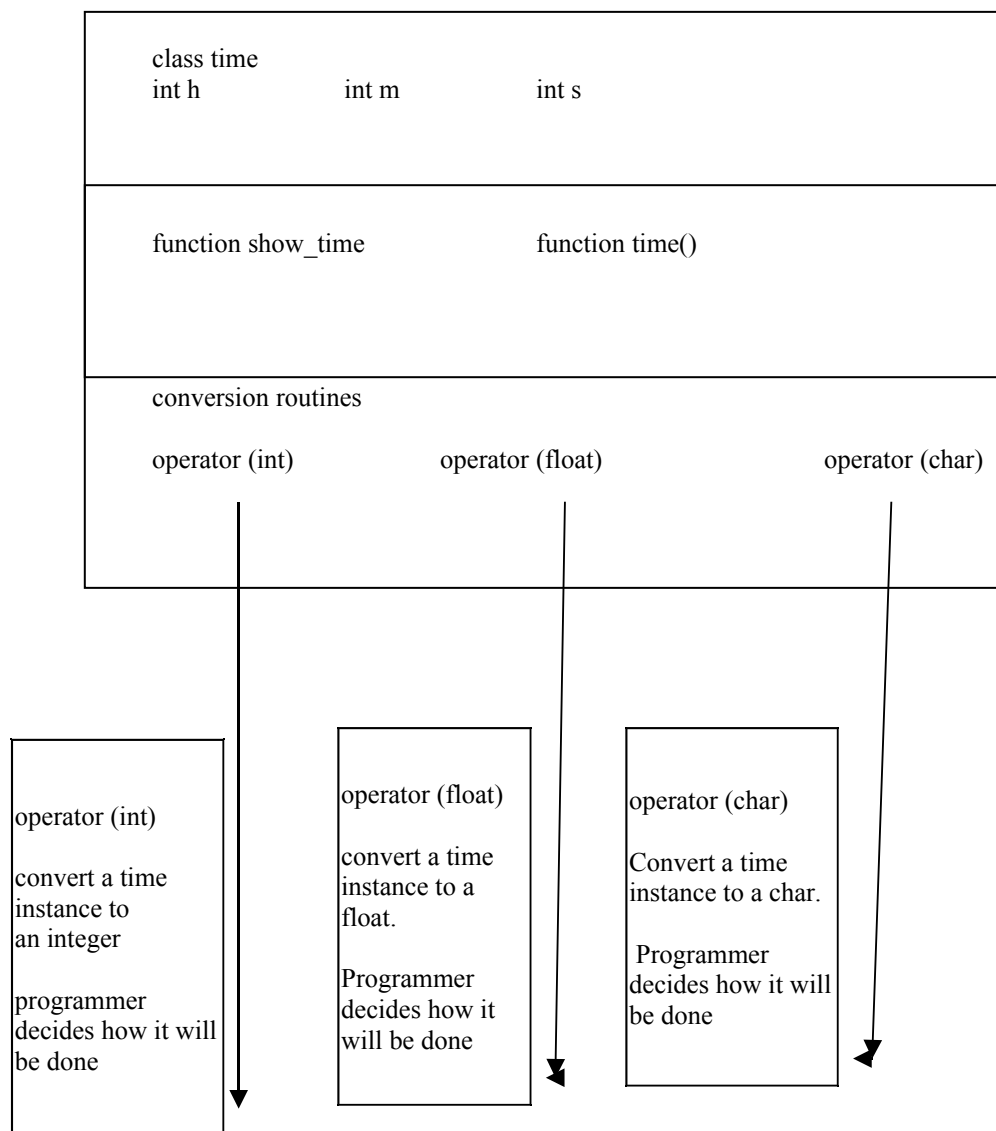
```

1 int main()
2 {
3     time t(1,2,3);
4
5     int i = 0;
6     float f = 0.0;
7     char c = 'C';
8
9     cout << "Before casting i is " << i << endl;
10    cout << "Before casting to int t is ";
11    t.show_time();
12    i = (int) t;      // now we don't call the subroutine like time_to_int, we just cast it
13                     // exactly the same amount of work will be done, in fact we end up calling
14                     // a subroutine that is suspiciously similar to time_to_int,
15                     // the point here isn't the efficiency of the language but the ease of use
16                     // of the language and the intuitiveness, the ability to use without learning,
17                     // of features of the language. Since C programmers already know casting
18                     // syntax, when using a user-defined class, they should be able to cast.
19    cout << "After casting i is " << i << endl;
20    cout << "After casting to int t is ";
21    t.show_time();
22
23    cout << "Before casting f is " << f << endl;
24    cout << "Before casting to float t is ";
25    t.show_time();
26    f = (float) t;
27    cout << "After casting f is " << f << endl;
28    cout << "After casting to float t is ";
29    t.show_time();
30
31    cout << "Before casting c is " << c << endl;
32    cout << "Before casting to char t is ";
33    t.show_time();
34    c = (char) t;
35    cout << "After casting c is " << c << endl;
36    cout << "After casting to char t is ";
37    t.show_time();
38}

```

1Output From Running Program
2
3Before casting i is 0
4Before casting to int t is h is 1
5m is 2
6s is 3
7
8The (int) operator was invoked
9After casting i is 1
10After casting to int t is h is 1
11m is 2
12s is 3
13
14Before casting f is 0
15Before casting to float t is h is 1
16m is 2
17s is 3
18
19The float operator was invoked
20After casting f is 6
21After casting to float t is h is 1
22m is 2
23s is 3
24
25Before casting c is C
26Before casting to char t is h is 1
27m is 2
28s is 3
29
30The char operator was invoked
31After casting c is a
32After casting to char t is h is 1
33m is 2
34s is 3

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```

1// castcons.cpp
2
3// So you say that's great, we can now turn a user defined type into any pre defined type
4// Well then, how do we cast a pre-defined type to a user-defined type?
5// Answer, you don't cast, you construct!
6// We have looked at constructors before, this program will look at them again, and will show how
7// One way that a programmer might have decided to build a time from many different combinations
8// and variations of pre defined types
9#include <iostream.h>
10
11// this program shows how a time could be built from
12// one int
13// two ints
14// three ints
15// one float
16// two floats
17// three floats
18// one char
19// two chars
20// three chars
21
22// these are all constructor functions
23
24class time
25{
26    private:
27        int h,m,s;           // hours, minutes, seconds
28
29    public:
30        void show_time();    // show what time it is
31
32        time(int);           // build a time from one int
33        time(int,int);       // build a time from two ints
34        time(int,int,int);   // build a time from three ints
35        time(float);         // build a time from one float
36        time(float,float);   // build a time from two floats
37        time(float,float,float); // build a time from three floats
38        time(char);          // build a time from one char
39        time(char,char);     // build a time from two chars
40        time(char,char,char); // build a time from three chars
41};
42
43void time::show_time()
44{
45    cout << "h is " << h << endl;
46    cout << "m is " << m << endl;
47    cout << "s is " << s << endl << endl;
48}
49

```

```

1// one int argument constructor
2time::time(int a) : h(a), m(0), s(0)
3{
4    cout << "One int arg constructor called \n";
5}
6// two int argument constructor
7time::time(int a, int b) : h(a), m(b), s(0)
8{
9    cout << "Two int arg constructor called \n";
10}
11// three int argument constructor
12time::time(int a, int b, int c) : h(a), m(b), s(c)
13{
14    cout << "Three int arg constructor called \n";
15}
16
17// one float argument constructor
18time::time(float a) : h( (int) a), m(0), s(0)
19{
20    cout << "One float arg constructor called \n";
21}
22// two float argument constructor
23time::time(float a, float b) : h( (int) a), m( (int) b), s(0)
24{
25    cout << "Two float arg constructor called \n";
26}
27// three float argument constructor
28time::time(float a, float b, float c) : h( (int) a), m( (int) b), s( (int)c)
29{
30    cout << "Three float arg constructor called \n";
31}
32
33// one char argument constructor
34time::time(char a) : h( (int) a), m(0), s(0)
35{
36    cout << "One Char arg constructor called \n";
37}
38// two char argument constructor
39time::time(char a, char b) : h((int) a), m( (int) b), s(0)
40{
41    cout << "Two Char arg constructor called \n";
42}
43// three char argument constructor
44time::time(char a, char b, char c) : h((int) a), m((int) b), s((int) c)
45{
46    cout << "Three Char arg constructor called \n";
47}

```

```

1 int main()
2 {
3     int i = 1;      int j = 2;      int k = 3;
4     char a = 'a';   char b = 'b';   char c = 'c';
5     float f = 10.1; float g = 20.2; float h = 30.3;
6
7     // build examples using all nine types of constructors
8     time d1(i);
9     cout << "d1 is ";
10    d1.show_time();
11
12    time d2(i,j);
13    cout << "d2 is ";
14    d2.show_time();
15
16    time d3(i,j,k);
17    cout << "d3 is ";
18    d3.show_time();
19    cout << endl;
20
21    time d4(f);
22    cout << "d4 is ";
23    d4.show_time();
24
25    time d5(f,g);
26    cout << "d5 is ";
27    d5.show_time();
28
29    time d6(f,g,h);
30    cout << "d6 is ";
31    d6.show_time();
32    cout << endl;
33
34    time d7(a);
35    cout << "d7 is ";
36    d7.show_time();
37
38    time d8(a,b);
39    cout << "d8 is ";
40    d8.show_time();
41
42    time d9(a,b,c);
43    cout << "d9 is ";
44    d9.show_time();
45 }

```

1Output From Running Program
2
3One int arg constructor called
4d1 is h is 1
5m is 0
6s is 0
7
8Two int arg constructor called
9d2 is h is 1
10m is 2
11s is 0
12
13Three int arg constructor called
14d3 is h is 1
15m is 2
16s is 3
17
18
19One float arg constructor called
20d4 is h is 10
21m is 0
22s is 0
23
24Two float arg constructor called
25d5 is h is 10
26m is 20
27s is 0
28
29Three float arg constructor called
30d6 is h is 10
31m is 20
32s is 30
33
34
35One Char arg constructor called
36d7 is h is 97
37m is 0
38s is 0
39
40Two Char arg constructor called
41d8 is h is 97
42m is 98
43s is 0
44
45Three Char arg constructor called
46d9 is h is 97
47m is 98
48s is 99
49
50

```

1// castcopy.cpp
2
3#include <iostream.h>
4
5// this program shows how a time could be built from another time
6// basically what we are doing is constructing one time from another tim
7// this is sometimes called the copy constructor
8// it is implemented using the operator =
9
10class time
11{
12    private:
13        int h,m,s;           // hours, minutes, seconds
14
15    public:
16        void show_time();    // show what time it is
17
18        time();              // no arg time constructor
19        time(int,int,int);   // three arg time constructor
20        time operator = (time); // "copy operator", or one arg where arg is time, constructor
21};
22
23void time::show_time()
24{
25    cout << "h is " << h << endl;
26    cout << "m is " << m << endl;
27    cout << "s is " << s << endl << endl;
28}
29
30// no int argument constructor
31time::time()
32{
33    cout << "No arg constructor called \n";
34    h = 12;
35    m = 34;
36    s = 56;
37}
38
39// three int argument constructor
40time::time(int a, int b, int c) : h(a), m(b), s(c)
41{
42    cout << "Three int arg constructor called \n";
43}

```


1 This subroutine will be called when someone uses syntax like
 2 `time t2 = t1;` where t1 was already defined somewhere else
 3 t2 will be created using the copy constructor

	class	function	argument
	membership	name	list
7			
8			
9			
10			
11			
12			
13	<code>time time::operator = (time t1)</code>		
14	{		
15	<code>cout << "The copy operator was invoked\n";</code>		
16	<code>this->h = t1.h;</code>		
17	<code>this->m = t1.m;</code>		
18	<code>this->s = t1.s;</code>		
19	<code>return *this;</code>		
20	}		
21			
22	<code>int main()</code>		
23	{		
24	<code>cout << "AAA\n";</code>		
25	<code>time t1;</code>		
26	<code>t1.show_time();</code>		
27			
28	<code>cout << "BBB" << endl;</code>		
29	<code>time t2(1,2,3);</code>		
30	<code>t2.show_time();</code>		
31			
32	<code>cout << "CCC " << endl;</code>		
33	<code>time t3 = t1;</code> // which constructor will be called?		
34	<code>t3.show_time();</code>		
35			
36	<code>cout << "DDD " << endl;</code>		
37	<code>t3 = t2;</code>		
38	<code>t3.show_time();</code>		
39	}		

1Output From Running Program
2
3AAA
4No arg constructor called
5h is 12
6m is 34
7s is 56
8
9BBB
10Three int arg constructor called
11h is 1
12m is 2
13s is 3
14
15CCC
16h is 12
17m is 34
18s is 56
19
20DDD
21The copy operator was invoked
22h is 1
23m is 2
24s is 3
25
26

1// **cls2stct.cpp**

```
2#include <iostream.h>
3// this program shows how a time class instance could be turned into a time structure
4// In going from a class object to a struct instance, we typically
5// will be going from a larger item to a smaller item because the struct
6// doesn't carry around the entry points to the functions like the class
7// does. However, the struct being converted to could have more fields
8// than the class object, and thus could be larger. The point of these
9// couple sentences is that we can make no assumptions about whether the
10// thing we are casting to is smaller or larger than the thing we are
11// casting from.
12
13// In this program I cast a time to an XXX which has one field, two less than a time.
14// I also cast a time to an MNOP which has four fields, one more than a time.
15
16struct XXX
17{
18    int x;
19};
20
21void print_XXX(XXX x1)
22{
23    cout << "value of field x is " << x1.x << endl;
24    cout << endl;
25}
26
27struct MNOP
28{
29    int m,n,o;
30    float p;
31};
32
33void print_MNOP(MNOP mnop1)
34{
35    cout << "value of field m is " << mnop1.m << endl;
36    cout << "value of field n is " << mnop1.n << endl;
37    cout << "value of field o is " << mnop1.o << endl;
38    cout << "value of field p is " << mnop1.p << endl;
39    cout << endl;
40}
41
42class time
43{
44    private:
45        int h,m,s;           // hours, minutes, seconds
46
47    public:
48        void show_time();     // show what time it is
49        time(int,int,int);
50        operator XXX ();      // turn a time into an XXX;
51        operator MNOP ();     // turn a time into an MNOP
52};
```

```

1 void time::show_time()
2 {
3     cout << "h is " << h << endl;
4     cout << "m is " << m << endl;
5     cout << "s is " << s << endl << endl;
6 }
7
8 // three int argument constructor
9 time::time(int a, int b, int c) : h(a), m(b), s(c)
10 {
11     cout << "Three int arg constructor called \n";
12 }
13
14 return    class    function    argument
15 type     membership name      list
16
17
18
19
20
21
22 time::operator XXX ()
23 {
24     // I made up the cast so I get to decide how to do it
25     // you could decide how to do it differently if you wrote the code
26     // that's the point, you get to decide how to convert one to the other
27     XXX temp;
28     temp.x = this->h + this->m + this->s;
29     return temp;
30 }
31
32 return    class    function    argument
33 type     membership name      list
34
35
36
37
38
39
40 time::operator MNOP ()
41 {
42     // I made up the cast so I get to decide how to do it
43     // you could decide how to do it differently if you wrote the code
44     // that's the point, you get to decide how to convert one to the other
45     MNOP temp;
46     temp.m = this->h;
47     temp.n = this->m;
48     temp.o = this->s;
49     temp.p = ( (float) this->h ) / ( (float) this->m );
50     return temp;
51 }

```

```

1 int main()
2 {
3     // create a time
4     time t1(4,2,1);
5     t1.show_time();
6
7
8     // this line will cast the time instance t1 into an XXX that can then be used in the
9     // XXX one argument copy constructor
10    // we did not write an XXX one argument copy constructor
11    // furthermore, XXX is a struct type not a class
12    // so where did the one arg copy constructor come from?
13    // C and C++ both provide default constructors for data types that do a memberwise
14    // copy from one instance of the type to another instance of that type
15    // remember in an earlier program we learned that = was the only operator defined for C structs
16    // well here is the consequence of having that = available
17    XXX x1 = (XXX) t1;
18    print_XXX(x1);
19
20    // this line will cast the time instance t1 into an MNOP that can then be used in the
21    // MNOP one argument copy constructor
22    MNOP m1 = (MNOP) t1;
23    print_MNOP(m1);
24 }

```

25 Output From Running Program

26 Three int arg constructor called

27 h is 4

28 m is 2

29 s is 1

30

31 value of field x is 7

32

33 value of field m is 4

34 value of field n is 2

35 value of field o is 1

36 value of field p is 2

37

38

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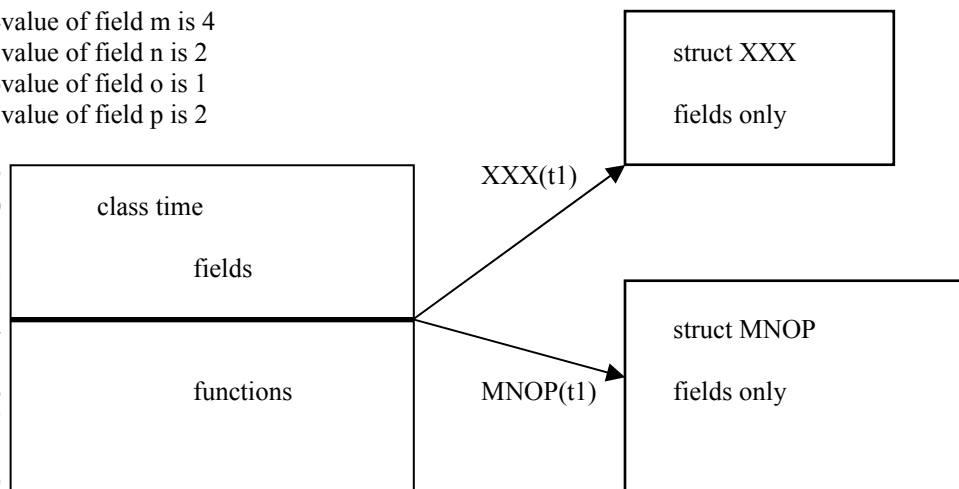
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```

1// stct2cls.cpp
2
3#include <iostream.h>
4
5// to convert a class to a struct, we need to build a constructor for
6// the class, we do not get to use the casting syntax because C structs
7// don't allow the inclusion of member functions and C++ classes do
8
9// In the next programs, cls2cls1.cpp and cls2cls2.cpp, we show casting
10// from a class to a class
11// Casting from a class to a class can be different than casting from a struct to class
12// C++ allows for special syntax and relationships between classes
13// One of the relationships is called INHERITANCE
14// We will cover inheritance in another section
15// So the next two programs, after this one, deal with casting from class to class
16// where there are and aren't inheritance relationships to INTRODUCE what the differences are
17// between embedding and inheritance
18
19struct XXX
20{
21    int x;
22};
23
24void print_XXX(XXX x1)
25{
26    cout << "value of field x is " << x1.x << endl;
27    cout << endl;
28}
29
30struct MNOP
31{
32    int m,n,o;
33    float p;
34};
35
36void print_MNOP(MNOP mnop1)
37{
38    cout << "value of field m is " << mnop1.m << endl;
39    cout << "value of field n is " << mnop1.n << endl;
40    cout << "value of field o is " << mnop1.o << endl;
41    cout << "value of field p is " << mnop1.p << endl;
42    cout << endl;
43}

```

```

1class time
2{
3    private:
4        int h,m,s;                // hours, minutes, seconds
5
6    public:
7        void show_time();          // show what time it is
8        time(int,int,int);
9        time( XXX );               // build a time from an XXX, this isn't casting, it is constructing
10       time ( MNOP );              // build a time from an MNOP, this isn't casting, it is constructing
11       operator XXX ();            // turn a time into an XXX;
12       operator MNOP ();           // turn a time into an MNOP
13};
14
15void time::show_time()
16{
17    cout << "h is " << h << endl;
18    cout << "m is " << m << endl;
19    cout << "s is " << s << endl << endl;
20}
21
22// three int argument constructor
23time::time(int a, int b, int c) : h(a), m(b), s(c)
24{
25    cout << "Three int arg constructor called \n";
26}
27
28time::operator XXX ()
29{
30    // I made up the cast so I get to decide how to do it
31    // you could decide how to do it differently if you wrote the code
32    // that's the point, you get to decide how to convert one to the other
33    XXX temp;
34    temp.x = this->h + this->m + this->s;
35    return temp;
36}
37
38time::operator MNOP ()
39{
40    // I made up the cast so I get to decide how to do it
41    // you could decide how to do it differently if you wrote the code
42    // that's the point, you get to decide how to convert one to the other
43    MNOP temp;
44    temp.m = this->h;
45    temp.n = this->m;
46    temp.o = this->s;
47    temp.p = ( (float) this->h ) / ( (float) this->m );
48    return temp;
49}
50

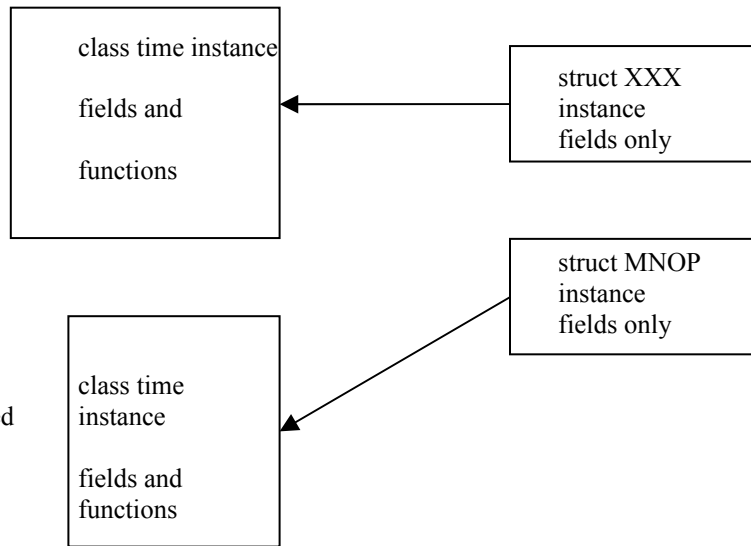
```

```

1// This is the function that will construct "cast" an XXX into a time
2return  class      function      argument
3type    membership  name         list
4
5
6
7
8
9
10time::time(XXX x1)
11{
12    cout << "The time(XXX) constructor was called \n";
13    h = x1.x;          // WHY did I decide to do it this way?
14    m = x1.x * 2;      // who knows, who cares, that's the point
15    s = x1.x * 4;      // you are in control, you can write the constructor
16}
17
18// note that this function also has the name time, however it has a different argument list
19// remember polymorphism? As long as the functions have different argument lists they can have
20// the same name. In both cases we are casting to a time using the casting syntax so this is a place
21// where having polymorphism available is an absolute necessity, Thank you Bjarne.
22time::time(MNOP m1)
23{
24    cout << "The time(MNOP) constructor was called \n";
25    h = m1.m;
26    m = m1.n + m1.o;
27    s = (int) m1.p + 10;
28}
29
30int main()
31{
32    // create a time
33    time t1(4,2,1);
34    t1.show_time();
35
36    // create an XXX from a time
37    XXX x1 = (XXX) t1;
38    print_XXX(x1);
39
40    // create an MNOP from a time
41    MNOP m1 = (MNOP) t1;
42    print_MNOP(m1);
43
44    XXX x2 = { 40 };
45    MNOP m2 = { 100,200,300,4.5 };
46
47    // create a time from an XXX
48    time t2(x2);
49    t2.show_time();
50
51    // create a time from an MNOP
52    time t3(m2);
53    t3.show_time();
54}

```


1Output From Running Program
2
3Three int arg constructor called
4h is 4
5m is 2
6s is 1
7
8value of field x is 7
9
10value of field m is 4
11value of field n is 2
12value of field o is 1
13value of field p is 2
14
15The time(XXX) constructor was called
16h is 40
17m is 80
18s is 160
19
20The time(MNOP) constructor was called
21h is 100
22m is 500
23s is 14



```

1// cls2cls1.cpp
2
3#include <iostream.h>
4
5// this program converts one class to another class and back from the other class to the first class
6
7// this presents a bit of a chicken and an egg problem
8// For one class to know how to convert to the other class the other class
9// has to already exist and yet for the other class to know how to convert
10// to the one class the one class has to already exist.
11// Well, not exactly.
12// C++ allows you enter the NAME of a class into the name space of the
13// compiler without actually implementing the class
14// Thus you can register the casting functions in the class definitions
15// and then, after both classes have been defined, implement the cast functions later
16
17class XXX;      // Enter the names of the two classes into the name space of the compiler
18class time;
19
20class XXX
21{
22    private:
23        int x;
24    public:
25        operator time();      // turn an XXX into a time
26        XXX(int);             // one int arg constructor
27        XXX();                 // no arg constructor
28        void show_XXX();
29};
30
31XXX::XXX() : x(10)
32{
33    cout << "NO arg XXX constructor called \n";
34}
35XXX::XXX(int xin) : x(xin)
36{
37    cout << "One int XXX constructor called \n";
38}
39
40void XXX::show_XXX()
41{
42    cout << "value of field x is " << x << endl;
43    cout << endl;
44}

```

```

1class time
2{
3    private:
4        int h,m,s;           // hours, minutes, seconds
5
6    public:
7        void show_time();    // show what time it is
8        time(int,int,int);
9        operator XXX ();     // turn a time into an XXX;
10};
11
12void time::show_time()
13{
14    cout << "h is " << h << endl;
15    cout << "m is " << m << endl;
16    cout << "s is " << s << endl << endl;
17}
18
19// three int argument constructor
20time::time(int a, int b, int c) : h(a), m(b), s(c)
21{
22    cout << "Three int arg constructor called \n";
23}
24// now that we have both classes implemented
25// we can write the casting routines
26
27return    class      function      argument
28type      membership  name          list
29
30
31
32
33time::operator XXX ()
34{
35    // I made up the cast so I get to decide how to do it
36    // you could decide how to do it differently if you wrote the code
37    // that's the point, you get to decide how to convert one to the other
38    XXX temp(this->h + this->m + this->s);
39    return temp;
40}
41
42return    class      function      argument
43type      membership  name          list
44
45
46
47
48
49XXX::operator time()
50{
51    time temp(this->x, this->x * 2, this->x * 4);
52    return temp;
53}

```

```

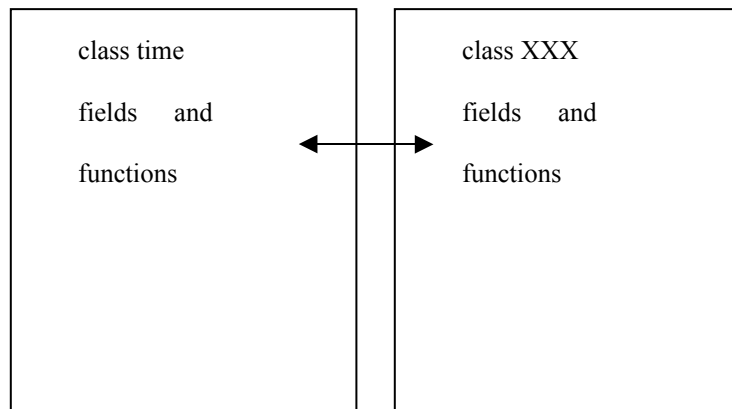
1int main()
2{
3    // create a time
4    time t1(4,2,1);
5    t1.show_time();
6    cout << endl;
7
8    // make an XXX out of it
9    XXX x1 = (XXX) t1;           // this casts the time instance t1 into an XXX
10   x1.show_XXX();
11   t1.show_time();              // t1 is not affected
12   cout << endl;
13
14   // create an XXX
15   XXX x2(12);
16   x2.show_XXX();
17   cout << endl;
18
19   // make a time out of it
20   time t2 = (time) x2;         // this casts the XXX instance x2 into a time
21   t2.show_time();
22   x2.show_XXX();               // x2 is not affected
23   cout << endl;
24}

```

```

25
26Output From Running Program
27Three int arg constructor called
28h is 4
29m is 2
30s is 1
31
32
33One int XXX constructor called
34value of field x is 7
35
36h is 4
37m is 2
38s is 1
39
40
41One int XXX constructor called
42value of field x is 12
43
44
45Three int arg constructor called
46h is 12
47m is 24
48s is 48
49
50value of field x is 12

```



```

1// cls2cls2.cpp
2
3#include <iostream.h>
4
5// this program converts one class to another class and back from the other
6// class to the first class where an inheritance relationship exists
7
8class XXX;
9class time;
10
11class XXX
12{
13    private:
14        int x;
15    public:
16        void setx(int);    // access routine for x
17        int getx();
18        XXX(int);          // one int arg constructor
19        void show_XXX();
20};
21
22XXX::XXX(int xin) : x(xin)
23{
24    cout << "One int XXX constructor called \n";
25}
26
27void XXX::setx(int i)
28{
29    x = i;
30    return;
31}
32
33int XXX::getx()
34{
35    return x;
36}
37
38void XXX::show_XXX()
39{
40    cout << "value of field x is " << x << endl;
41    cout << endl;
42}

```

1 This class inherits from the XXX class
 2 What that means is that a time IS an XXX AND the extra stuff declared in here
 3
 4 We will do much more work with inheritance in later sections
 5 I have included this program here to illustrate the casting differences when inheritance is involved
 6 Perhaps you want to skip this program now and come back to it after you fully understand inheritance

```

7
8 class      inheritance      base
9 name      type      class name
10
11
12
13
14
15
16
17 class time : public XXX
18 {
19     private:
20         int h,m,s;          // hours, minutes, seconds
21
22     public:
23         void show_time();    // show what time it is
24         time(int,int,int);    // how to build a time from three ints
25         time(XXX);           // how to build a time from an XXX
26
27         // we don't have to write this routine anymore when inheritance is involved
28         // C++ already has a method, that you should just accept, for converting a derived instance
29         // into a base instance. It hacks off all the extra parts of the derived portion and just leaves
30         // the base class portion of the derived object. This is known as the Manassis approach.
31         //operator XXX ();    // turn a time into an XXX;
32         time operator = (time); // copy one time to another time
33 };
34
35 time time::operator = (time t1)
36 {
37     this->h = t1.h;
38     this->m = t1.m;
39     this->s = t1.s;
40     this->setx(-99);
41     return *this;
42 }
43
44 void time::show_time()
45 {
46     cout << "the x part of the base portion is " <<
47     this->getx() << endl;
48     cout << "h is " << h << endl;
49     cout << "m is " << m << endl;
50     cout << "s is " << s << endl << endl;
51 }

```

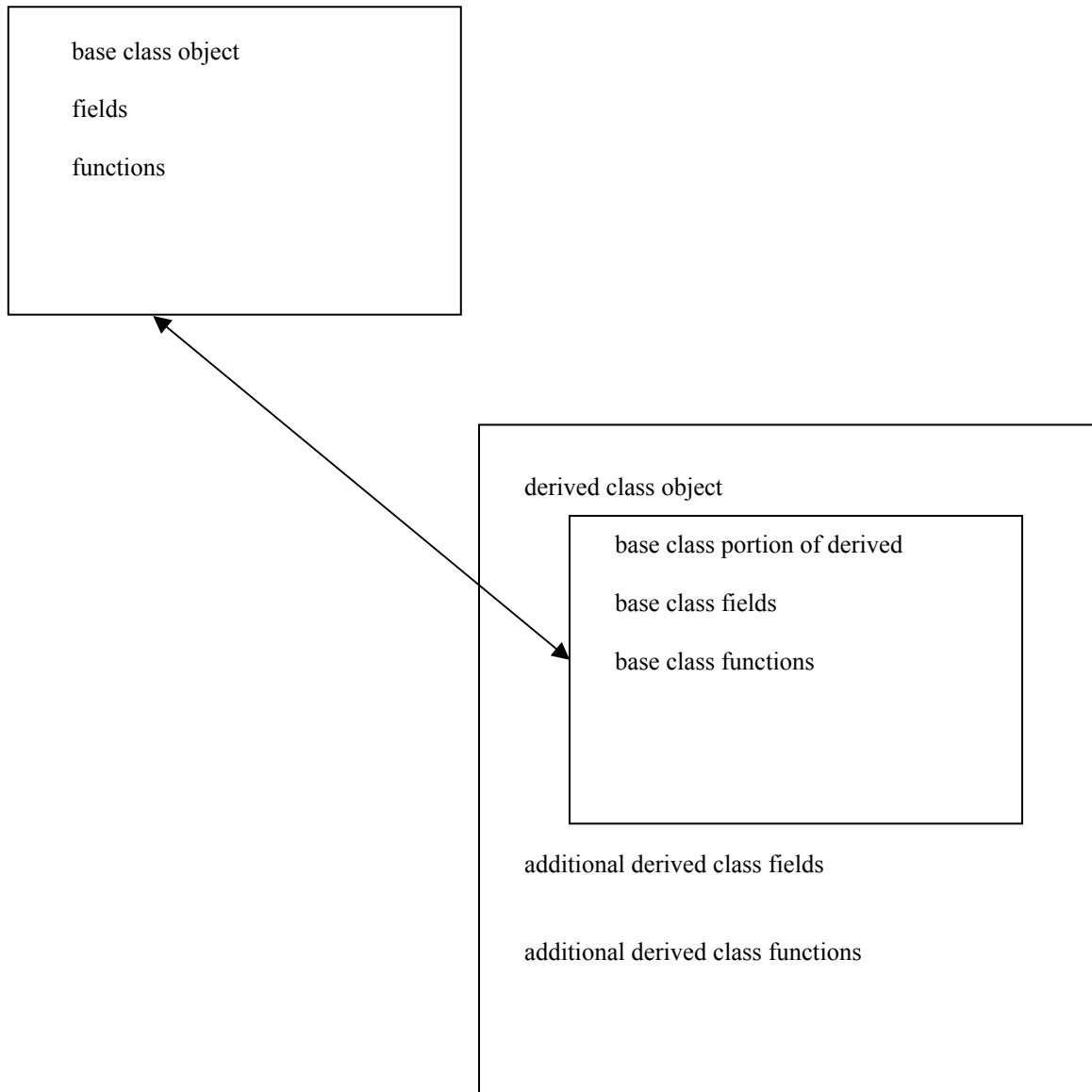
```

1// three int argument constructor
2time::time(int a, int b, int c) : h(a), m(b), s(c), XXX(4567)
3{      cout << "Three int arg constructor called \n";      }
4
5#ifdef 0
6WE DON'T HAVE TO WRITE THIS ROUTINE, C++ ALREADY KNOWS HOW TO DO THIS
7XXX time::operator XXX ()
8{
9      // I made up the cast so I get to decide how to do it
10     // you could decide how to do it differently if you wrote the code
11     // that's the point, you get to decide how to convert one to the other
12     XXX temp(this->getx() );
13     return temp;
14}
15#endif
16
17// We still write the XXX to time class cast "Constructor" in this case.
18// we can build a derived object from a base object by adding on the extra fields and entry points
19time::time(XXX inx) : XXX(0)
20{
21     // leave x with whatever value it had
22     // we are basically building a new XXX AND a time
23     this->setx(inx.getx() );
24     h = -1;  m = -2;  s = -3;
25}
26
27int main()
28{
29     XXX x1(12);    // create an XXX
30     x1.show_XXX();
31     cout << endl;
32
33     time t1(4,2,1);    // create a time
34     t1.show_time();
35     cout << endl;
36
37     // create an XXX out of a time
38     cout << endl << "t1 and x1 before assignment " << endl;
39     t1.show_time();
40     x1.show_XXX();
41     // x1 = (XXX) t1;      // don't need the cast syntax
42     x1 = t1;              // C++ just knows how to do this, because C++ has the = operator
43                          // defined between any two instances of the same type, and since a
44                          // time IS an XXX, it copies the like fields and drops the unlike
45     cout << endl << "t1 and x1 after assignment " << endl;
46     t1.show_time();
47     x1.show_XXX();
48
49     time t2(12,34,56);
50     t2.show_time();
51     t2 = t1;
52     t2.show_time();
53}

```

```
1Output From Running Program
2
3One int XXX constructor called
4value of field x is 12
5
6
7One int XXX constructor called
8Three int arg constructor called
9the x part of the base portion is 4567
10h is 4
11m is 2
12s is 1
13
14
15
16t1 and x1 before assignment
17the x part of the base portion is 4567
18h is 4
19m is 2
20s is 1
21
22value of field x is 12
23
24
25t1 and x1 after assignment
26the x part of the base portion is 4567
27h is 4
28m is 2
29s is 1
30
31value of field x is 4567
32
33One int XXX constructor called
34Three int arg constructor called
35the x part of the base portion is 4567
36h is 12
37m is 34
38s is 56
39
40the x part of the base portion is -99
41h is 4
42m is 2
43s is 1
44
45
```


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1Section 6

2

3This section is about inheritance.

4C++ is all about classes.

5Once you know about classes, then you can get sophisticated and learn about inheritance.

6

7Object oriented analysis and design requires classes.

8Good object oriented analysis and design requires inheritance.

9It is a thorough understanding of what inheritance is and what it can do for you that takes you from the
10ranks of the novice C++ programmer to the good C++ programmer.

11

12If you want to use C++ as more than just a better C compiler, then focus your study on classes and
13inheritance.

14

15This section explains what inheritance is not. Many people EMBED things and think they're doing
16inheritance. They aren't.

17

18Inheritance implements the "IS A" relationship.

19Embedding implements the "Has A" relationship.

20

21For example, a car has an engine.

22 a car is not an engine.

23 therefore a car does not inherit from an engine.

24

25 a car is a vehicle.

26 therefore a car inherits from a vehicle.

27 a base class of vehicle could be established where the common fields and functions
28 for all vehicles could be isolated. This would greatly reduce the number of
29 places that the code for vehicle would need to be maintained.

30 the deriving classes, cars and trucks etc... would all be considered vehicles AND
31 the extra fields and functions that make them different.

32

33 Deriving classes are also able to redefine a field or function found in a base class.

34 Without this last point, inheritance would be too restrictive.

35

36This section shows you **EVERY** rule and regulation and possibility of inheritance.

37

38embed.cpp one class embedded in another, not an inheritance relationship

39

40base_a.cpp a class that can stand by itself and be used as a base class

41

42tstbasea.cpp program to exercise base_a

43

44puba.cpp a class that derives using public inheritance from base class coded in base_a.cpp

45

46pubinht.cpp program to exercise class puba

47

48priva.cpp a class that derives using private inheritance from base class coded in base_a.cpp

49

50privinht.cpp program to exercise derived class priva

51

52polyinh1.cpp polymorphism in an inheritance relationship

53

54

1// **embed.cpp**

```
2// this program illustrates the fact that one class can be embedded inside
3// of another. This is NOT inheritance. We will see inheritance very soon
4
5// Each of the functions does something simple and prints out that it was
6// called. What each function does in this example is not important
7// What functions can and can't be called from where and by whom IS important
8#include <iostream.h>
9
10class a
11{
12    private:
13        int a;
14    public:
15        a(void);           // no arg constructor
16        void seta(int);
17        void printa(void);
18};
19
20a::a() : a(23)
21{
22    cout << "No arg constructor for a was called \n";
23}
24
25void a::seta(int x )
26{
27    cout << "a::seta function was called \n";
28    a = x;
29}
30
31void a::printa(void)
32{
33    cout << "a::printa function called, a is " << a << endl;
34}
```

```

1 This class is going to have an instance of an A embedded in it
2 Question?      What functions of a can the b instance call?
3               There are two places to examine.
4               From within the member code of a b instance
5               From user code, i.e. main, that is not part of the b member functions
6
7 class b
8 {
9     private:
10         int    b;        // b is an integer
11         a      a1;        // a1 is of type a  B HAS AN INSTANCE OF AN A EMBEDDED IN IT
12                     // a1 is of a user defined type, not a pre-defined type
13     public:
14         b(void);          // no arg constructor
15         void setb(int);    // function to set b
16         void printb(void);
17         void setb_and_a1(int,int);
18 };
19
20 // this is the no arg constructor for b
21 // before the first executable statement in the constructor can be executed
22 // ALL of the memory for the instance must be allocated
23 // The system will cause the no arg constructor for type a to be called because a1 is of type a
24 b::b() : b(-97)
25 {
26     // before the first line of the constructor is called, the memory for the a that is
27     // part of this b instance, is allocated and initialized using the appropriate constructor
28     // in this case we gave no information about what constructor to use for the a portion
29     // therefore, the no argument constructor for the a part was called
30     cout << "No arg constructor for b was called \n";
31 }
32
33 // function to set the integer portion of b
34 void b::setb(int x )
35 {
36     cout << "b::setb function was called \n";
37     b = x;    // You can do this because b is private data of the class b
38 }
39
40 // function to set BOTH fields
41 void b::setb_and_a1(int x, int y)
42 {
43     b = x;        // you can do this
44     //a = y;       // you cannot do this because a is private data of a1
45     a1.seta(y);    // you are forced to do this, call a PUBLIC member function of an a instance
46 }

```

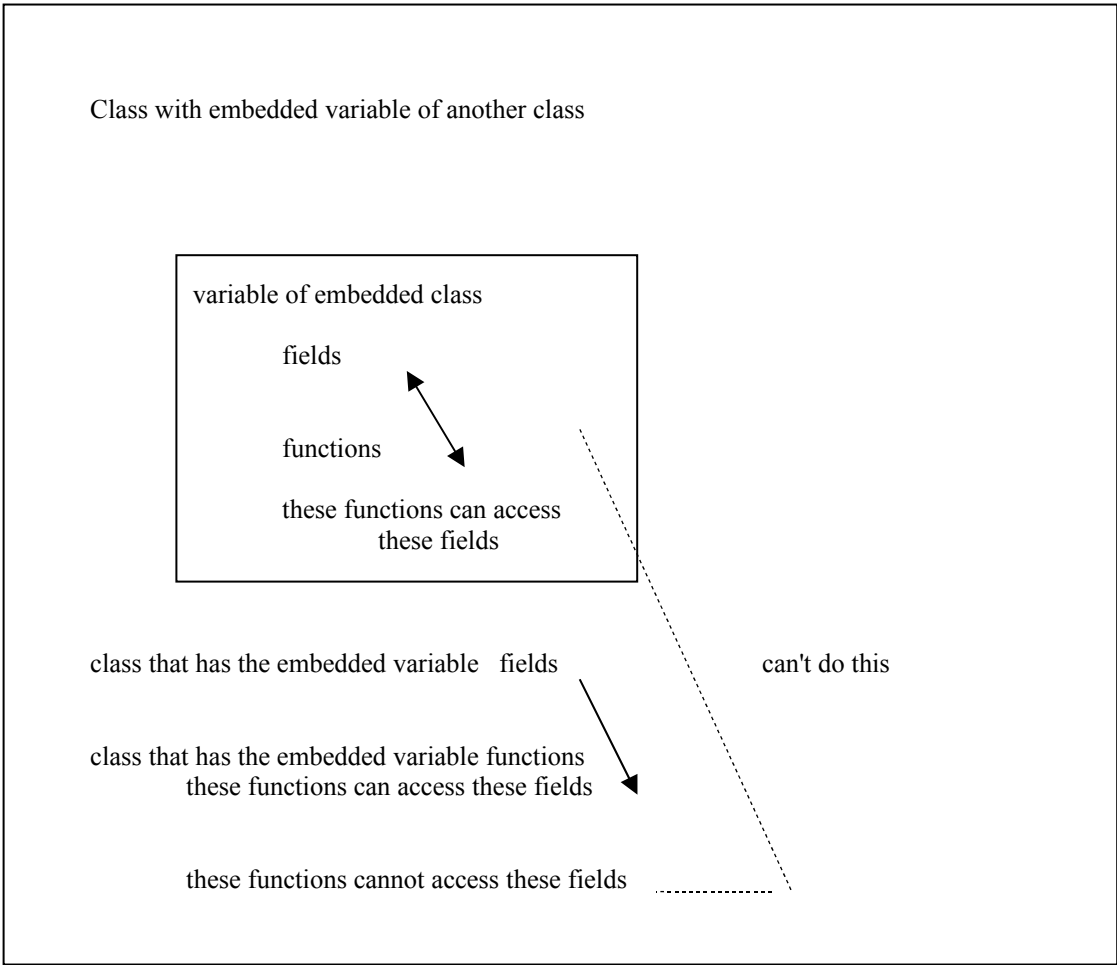
```

1 void b::printb(void)
2 {
3     // you can do this
4     cout << "b::printb function called, b is " << b << endl;
5
6     // you can't do this because a1 is private data of the a class and this is not a
7     // member function of the a class
8     // cout << "b::printb function called, a1 is " << a1 << endl;
9
10    // you are forced to do this, call the PUBLIC member function that knows how to print an a
11    a1.printa();
12}
13
14main()
15{
16    // declare a variable of type a
17    a      abc;
18    abc.printa();    // a is a class in and of itself, it's variables can be accessed by the functions
19    abc.seta(88);    // assigned to do that job
20    abc.printa();
21
22    // declare a variable of type b, a variable of type b has a variable of type a embedded in it
23    b      xyz;
24    xyz.printb();
25    // xyz.printa();    // you can't do this, printa is a member function of class a, not of class b
26                        // if class b had INHERITED from class a, then you COULD have made
27                        // this call, we will see this in the inheritance section
28
29    xyz.setb(34);    // you can do this
30    // xyz.seta(345); // you can't do this because seta is a member function of class a, not class b
31
32    xyz.setb_and_a1(-23,-654);    // we need a special function to access
33                                // the a part of the b class variable
34    xyz.printb();
35}
36
37Output From Running Program
38
39No arg constructor for a was called
40a::printa function called, a is 23
41a::seta function was called
42a::printa function called, a is 88
43
44No arg constructor for a was called    This happened on line    b xyz;
45No arg constructor for b was called
46b::printb function called, b is -97
47a::printa function called, a is 23
48b::setb function was called
49a::seta function was called
50b::printb function called, b is -23
51a::printa function called, a is -654
52

```

1Embedding Diagram

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```

1// base_a.cpp
2#ifndef BASEACPP
3#define BASEACPP
4the first time this file is included into a compile list, the COMPILER variable BASEACPP is not "defined",
5therefore #ifndef is TRUE therefore we compile the source contained within the #ifndef #endif block. In
6subsequent inclusions for the same compile list for the same load module, the compiler variable
7BASEACPP is "defined", because the #define BASEACPP line was encountered. Therefore the #ifndef
8BASEACPP is FALSE and the source code is not included again.
9
10// this file lays out a class that is destined to be used as a BASE class
11// Just because something will be used as a base class doesn't mean that it can't be used
12// all by itself as a regular class. There is no special syntax for classes that will be base classes
13// There exist in and of and by themselves as regular classes UNTIL some other class issues special
14// syntax that identifies that they wish to derive from some other class. At that point they become a
15// base class. However, even after they have been identified by an inheritor as its base class, they can
16// still function as regular classes. Being a base class places no restrictions on a class
17
18// Any class may have three portions:
19//     private:
20//     protected:
21//     public:
22
23// Each of these sections may have data and functions
24
25// We start our derivation of inheritance by examining what these three
26// sections mean with respect to the visibility and accesibility of the
27// variables and subroutines declared in each area
28
29// There are two places where the visibility needs to be examined
30//     in code that is part of the subroutines that are part of the class
31//     in code that is not part of the subroutines that are part of the class
32//     (i.e. in main )
33
34#include <iostream.h>
35
36class a
37{
38    private:
39        int    a_priv_var;           // a private variable
40        void    a_private_fl();       // a private function
41    protected:
42        int    a_prot_var;           // a protected variable
43        void    a_protected_fl();     // a protected function
44    public:
45        int a_pub_var;               // a public variable
46        void    a_public_fl();        // a public function
47
48        a();                         // no arg constructor
49        void a_print();              // another public function
50        void a_call_em();            // another public function
51};

```

```

1// no argument constructor
2a::a()
3{
4    cout << "The a no arg constructor has been invoked \n";
5    a_priv_var = 1;
6    a_prot_var = 2;
7    a_pub_var = 3;
8}
9
10// this is a private member function of the a class
11// from inside a private member function you can access
12// private, protected, public data
13void a::a_private_f1()
14{
15    cout << "In a_private_f1 "
16    << a_priv_var // we have access to private data
17    << " "
18    << a_prot_var // we have access to protected data
19    << " "
20    << a_pub_var // we have access to public data
21    << " "
22    << endl;
23}
24
25// this is a protected member function of the a class
26// from inside a protected member function you can access
27// private, protected, public data
28void a::a_protected_f1()
29{
30    cout << "In a_protected_f1 "
31    << a_priv_var // we have access to private data
32    << " "
33    << a_prot_var // we have access to protected data
34    << " "
35    << a_pub_var // we have access to public data
36    << " "
37    << endl;
38}
39
40// this is a public member function of the a class
41// from inside a public member function you can access
42// public, protected and private data
43void a::a_public_f1()
44{
45    cout << "In a_public_f1 "
46    << a_priv_var // we have access to private data
47    << " "
48    << a_prot_var // we have access to protected data
49    << " "
50    << a_pub_var // we have access to public data
51    << " "
52    << endl;
53}

```

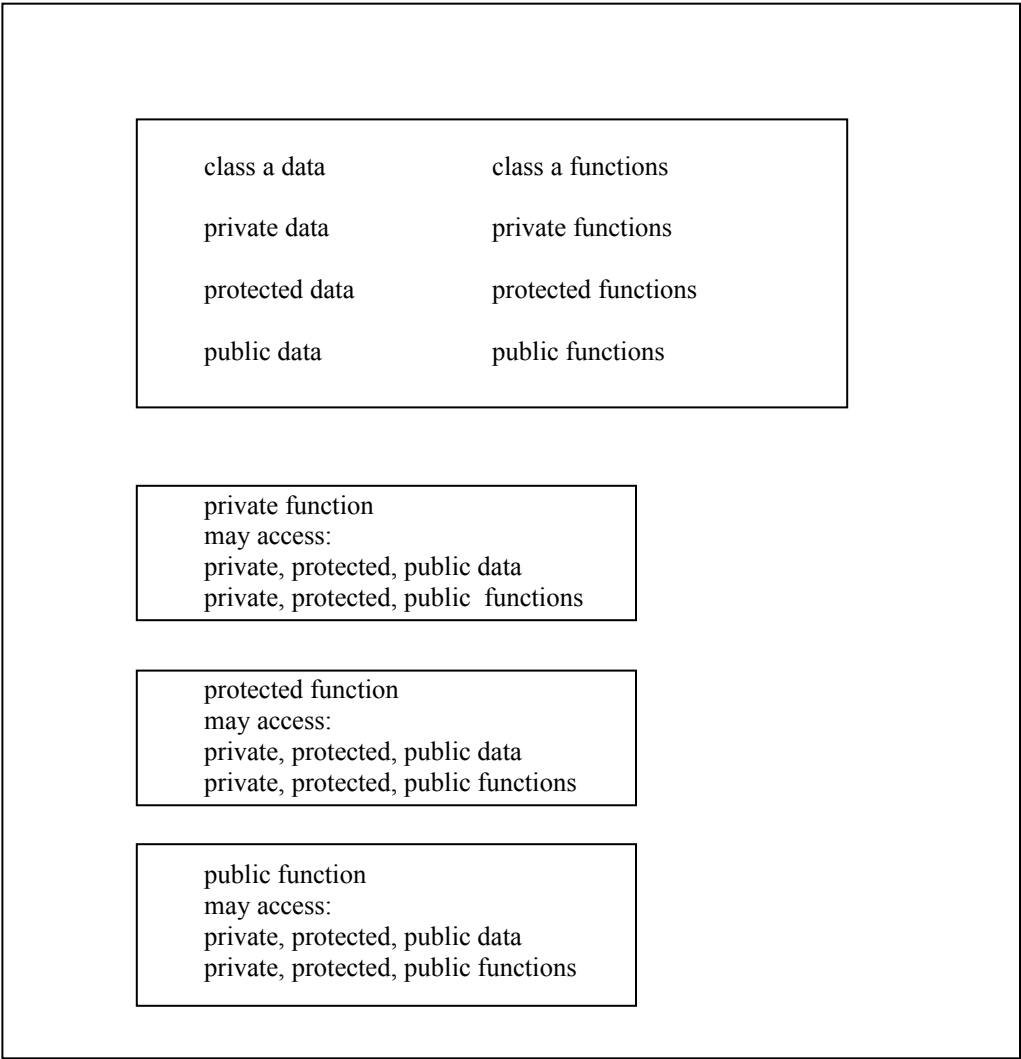


```

1// this is a public member function that can access all three types of data
2void a::a_print()
3{
4    cout << "In a_print "
5    <<    a_priv_var    // we have access to private data
6    << " "
7    <<    a_prot_var    // we have access to protected data
8    << " "
9    <<    a_pub_var    // we have access to public data
10   << " "
11   <<    endl;
12}
13
14// this is a public member function
15// from a public member function you may access the
16// public, protected and private member functions
17void a::a_call_em()
18{
19    this->a_private_fl();
20    this->a_protected_fl();
21    this->a_public_fl();
22}
23
24// this class definition will be used in several C++ programs
25// therefore it is left by itself in this file with no main
26// immediately associated with it
27// it will be compiled with other sources to form a complete program
28// this #endif is the end of the #ifndef #endif block used to "protect" this file from multiple inclusions
29#endif

```

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1// **tstbasea.cpp**

```
2// this program exercises the base class a as a stand alone class
3// it will be used as the base class for other objects
4// it is purely a teaching class object
5// it has public, private and protected data and functions
6// just because it is going to be a base class doesn't mean it can't
7// function as a regular class all by itself.
8
9// the first thing you have to be completely clear about is who can
10// access the public, private and protected elements of the class
11
12// there are two places we have to examine each of these three areas from:
13//     from within the code of a member function
14//     from outside the scope of any member function (i.e. in main)
15
16// The basic access rules are:
17//     Any member function can access any public, private or protected
18//         data element of its own class
19//     Any member function can access any public, private or protected
20//         member function of its own class
21
22//     No non member function code can access any private or protected
23//         data element of any class
24//     No non member function code can access any private or protected
25//         member function of any class
26
27//     Any non member function code can access any public data of any class
28//     Any non member function code can access any public function of any class
```

```

1#include "base_a.cpp"
2#include <iostream.h>
3
4main()
5{
6    // You can create an instance of a base class object
7    a obj1;
8    obj1.a_print();
9
10   // You can call the public member functions
11   obj1.a_print();
12   obj1.a_public_fl();
13
14   // You cannot call the protected member functions from outside
15   // a member function of the class
16   // obj1.a_protected_fl();
17
18   // You cannot call the private member functions from outside
19   // a member function of the class
20   // obj1.a_private_fl();
21
22   // You can call a public member function that calls the
23   // public, protected and private member functions
24   // this is the only way you are going to get access to the protected and private data of the class
25   obj1.a_call_em();
26
27   // examine the accessibility of the variables
28   // obj1.a_priv_var = 1;    // this variable is not visible from non member functions
29   // obj1.a_prot_var = 1;    // this variable is not visible from non member functions
30   obj1.a_pub_var = 1;       // this variable, a public variable, is visible
31}
32
33Output From Running Program
34
35The a no arg constructor has been invoked
36In a_print 1 2 3
37In a_print 1 2 3
38In a_public_fl 1 2 3
39In a_private_fl 1 2 3
40In a_protected_fl 1 2 3
41In a_public_fl 1 2 3

```

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class a data	class a functions
private data	private functions
protected data	protected functions
public data	public functions

private function
may access:
private, protected, public data
private, protected, public functions

protected function
may access:
private, protected, public data
private, protected, public functions

public function
may access:
private, protected, public data
private, protected, public functions

main()

may access:
 public data of any class
 public functions of any class

may not access:
 protected data of any class
 protected functions of any class
 private data of any class
 private functions of any class

1// puba.cpp

```
2
3#ifndef PUBACPP
4#define PUBACPP
5
6// this file introduces the class puba
7// it INHERITS from the class a
8// it inherits using the public inheritance mechanism
9// there are two types of inheritance, public and private
10
11// Inheritance means that an object of type puba is an object of type a AND
12// some extra stuff
13
14
15     base class portion
16     base class fields      base class functions
17
18     -----
19     derived class portion
20     derived class fields    derived class functions
21
22
23// there are visibility issues in a derived class object
24#include <iostream.h>
25#include "base_a.cpp"
26// the class name is puba
27// it inherits from a
28// using the public mechanism
29class puba : public a
30{
31    private:
32        int puba_priv_var;           // private data field
33        void puba_private_f1();      // private member function
34    protected:
35        int puba_prot_var;           // protected data field
36        void puba_protected_f1();    // protected member function
37    public:
38        int puba_pub_var;            // public data field
39        void puba_public_f1();        // public member function
40        puba();                      // constructor
41        void puba_print();            // public member function
42        void puba_call_em();          // public member function
43};
```

```

1
2// Notice that we are specifying the way in which we want the three variables of the derived portion
3// to be initialized. However, we have not said how we want the variables of the base class portion
4// of the object to be initialized. Because of this, the default, no arg constructor for the base class
5// will be invoked
6
7puba::puba() : puba_priv_var(10), puba_prot_var(20), puba_pub_var(30)
8{
9    // before the first line in the derived class constructor is executed
10   // ALL the memory for the entire object has to be allocated
11   // since an object of type puba IS an object of type a AND some other
12   // stuff, the constructor for the a portion of puba object will be
13   // invoked before the first executable statement in this constructor
14   // is executed
15
16   // you will notice the print out from the a class constructor before
17   // the print out from this constructor
18   cout << "In puba no arg constructor \n";
19}
20
21// this is a private member function of the derived class
22// it has access to the public, protected and private data of the puba class
23// it has access to the public and protected variables of the a class
24// it DOES NOT have access to the private data of the a class
25void puba::puba_private_f1()
26{
27    cout << "In puba_private_f1 " << endl;
28    // examine accessability to the puba portion variables
29    cout << "puba_priv_var is: "
30    << puba_priv_var
31    << " puba_prot_var is: "
32    << puba_prot_var
33    << " puba_pub_var is: "
34    << puba_pub_var
35    << endl;
36
37    // remember what happened when we EMBEDDED an instance of one class in another class?
38    // none of the data was visible to the class that had the instance embedded in it.
39    // Now that we are doing INHERITANCE, the public and protected portions will be visible
40    // examine accessability to variables of base class
41    cout << "a_priv_var " << a_priv_var // this variable is not visible, it is private data of the base class
42    << "a_prot_var " << a_prot_var // this variable is visible, it is protected data of the base class
43    << " "
44    << "a_pub_var " << a_pub_var // this variable is visible, it is public data of the base class
45    << endl;
46}

```

```

1// this is a protected member function of the derived class
2// it has access to the public, protected and private data of the puba class
3// it has access to the public and protected variables of the a class
4// it DOES NOT have access to the private data of the a class
5void puba::puba_protected_fl()
6{
7    cout << "In puba_protected_fl " << endl;
8    // examine accessability to variables of the puba portion
9    cout << "puba_priv_var is: "
10   << puba_priv_var
11   << " puba_prot_var is: "
12   << puba_prot_var
13   << " puba_pub_var is: "
14   << puba_pub_var
15   << endl;
16
17   // examine accessability to variables of base class
18   cout << "a_priv_var " << // this variable is not visible
19   << a_prot_var
20   << " "
21   << a_pub_var
22   << endl;
23
24
25// this is a public member function of the derived class
26// it has access to the public, protected and private data of the puba class
27// it has access to the public and protected variables of the a class
28// it DOES NOT have access to the private data of the a class
29void puba::puba_public_fl()
30{
31    cout << "In puba_public_fl " << endl;
32    // examine accessability of puba portion of the class variables
33    cout << "puba_priv_var is: "
34    << puba_priv_var
35    << " puba_prot_var is: "
36    << puba_prot_var
37    << " puba_pub_var is: "
38    << puba_pub_var
39    << endl;
40
41    // examine accessability to variables of base class
42    cout << "a_priv_var " << // this variable is not visible
43    << a_prot_var
44    << " "
45    << a_pub_var
46    << endl;
47}

```

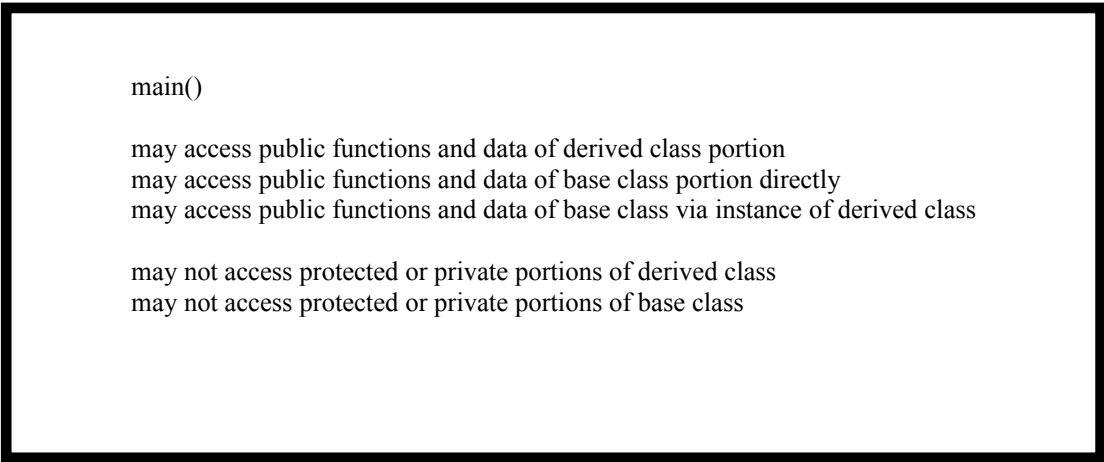
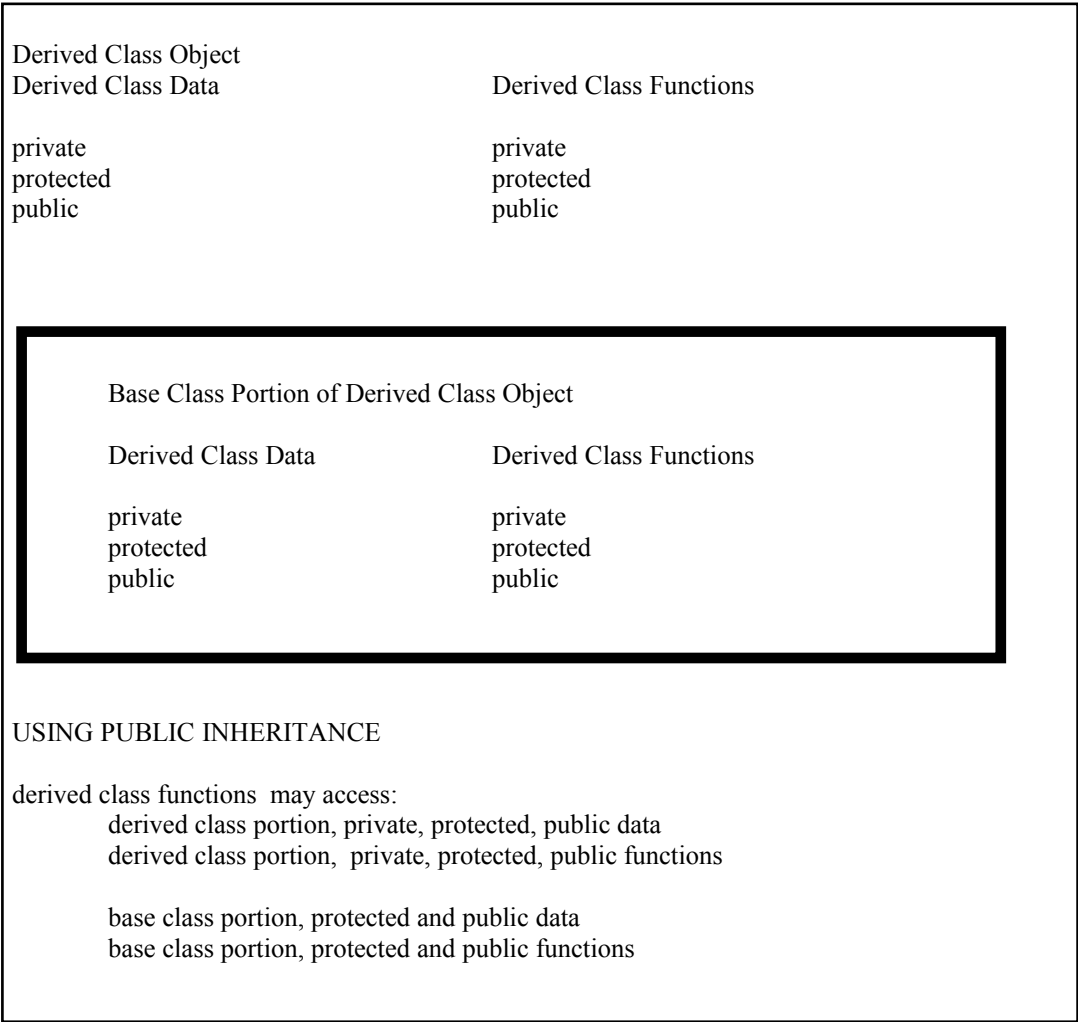


```

1// this public member function has access to all three types of data that
2// are part of the puba portion of a puba object
3// it has access to the public and protected data of the base class portion
4// of the puba object
5// it DOES NOT have access to the private data of the base class portion
6// of the puba object
7void puba::puba_print()
8{
9// from inside a member function, public, protected or private
10// you can access the public, protected and private data elements
11    cout << "puba_priv_var is: "
12    << puba_priv_var
13    << " puba_prot_var is: "
14    << puba_prot_var
15    << " puba_pub_var is: "
16    << puba_pub_var
17    << endl;
18
19    cout // << a_priv_var    // this variable is not visible
20    << a_prot_var
21    << " "
22    << a_pub_var
23    << endl;
24}
25
26// this is a public member function
27// it can call the private, protected and public member functions of the
28// puba portion of the puba class
29// it can call the protected and public member functions of the a portion
30// of the puba class
31void puba::puba_call_em()
32{
33    // from inside a member function, you can call any other
34    // member function of its own class
35    this->puba_private_fl();
36    this->puba_protected_fl();
37    this->puba_public_fl();
38
39    // examine accessibility of functions in base class
40    // from inside a member function that derives from another class, you may access the protected
41    // and public functions of the base class. From inside a member function that derives from
42    // another
43    // class you MAY NOT access the private functions of the base class
44    // this->a_private_fl();    // this function is not visible
45    this->a_protected_fl();
46    this->a_public_fl();
47}
48#endif

```

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```

1// pubinht.cpp
2
3// this program exercises the class puba which is derived from
4// the base class a
5// it uses public inheritance
6// because public inheritance is used, certain rules apply to what code
7// has access to the public, private and protected data and member functions
8// of the base class
9// the access rules for the derived class are also spelled out in this program
10
11// the base class has three areas to examine, public, protected, private
12// the derived class has three areas to examine, public, protected, private
13
14// there are three places we have to examine each of these three areas from:
15//   from within the code of a member function of the base class
16//   from within the code of a member function of the deriving class
17//   from outside the scope of any member function (i.e. in main)
18
19// The basic access rules are:
20//   Any member function can access any public, private or protected
21//       data element of its own class
22//   Any member function can access any public, private or protected
23//       member function of its own class
24
25//   No non member function code can access any private or protected
26//       data element of any class
27//   No non member function code can access any private or protected
28//       member function of any class
29
30//   Any non member function code can access any public data
31//   Any non member function code can access any public function

```

```

1#include <iostream.h>
2#include "base_a.cpp"
3#include "puba.cpp"
4
5main()
6{
7    // You can create an instance of a base class object
8    a obj1;
9    obj1.a_print();
10
11    // You can call the public member functions of the base class object
12    obj1.a_print();
13    obj1.a_public_f1();
14
15    // You cannot call the protected member functions from outside
16    // a member function of the class
17    // obj1.a_protected_f1();
18
19    // You cannot call the private member functions from outside
20    // a member function of the class
21    // obj1.a_private_f1();
22
23    // You can call a public member function that calls the
24    // public, protected and private member functions
25    obj1.a_call_em();
26
27    puba obj2;           // you can create an object of derived class
28    obj2.puba_print();    // we can call the public print function of the derived class
29    obj2.a_print();       // we can call the public print function of
30                          // the class from which it is derived
31
32    obj2.puba_public_f1(); // can call the public function
33                          // of the puba portion of the class
34    // obj2.puba_protected_f1(); // protected function not visible
35    // obj2.puba_private_f1(); // private function not visible
36
37    obj2.a_public_f1();    // can call the public function of the base class portion of an
38                          // object of type puba
39    // obj2.a_protected_f1(); // protected function not visible
40    // obj2.a_private_f1();  // private function not visible
41
42    obj2.puba_call_em();   // can call public function of the derived portion of the class

```

```

1      // examine accessibility of member variables of base object
2      // via an instance of the base object
3      // obj1.a_priv_var = 100; // private variable is not visible
4      // obj1.a_prot_var = 100; // protected variable is not visible
5      obj1.a_pub_var = 100;    // public data is visible
6
7      // examine accessibility of member variables of derived class portion
8      // of puba object via an instance of the derived object
9      // obj2.puba_priv_var = 200;    // private variable is not visible
10     // obj2.puba_prot_var = 200;    // protected variable is not visible
11     obj2.puba_pub_var = 200;    // public data is visible
12
13     // examine the accessibility of member variables of base portion of
14     // puba object via an instance of a derived object
15     // obj2.puba_priv_var = 300;    // variable is not visible
16     // obj2.puba_prot_var = 300;    // variable is not visible
17     obj2.puba_pub_var = 300;
18}

```

```
1Output From Running Program
2
3The a no arg constructor has been invoked
4In a _print 1 2 3
5In a _print 1 2 3
6In a _public_fl 1 2 3
7In a _private_fl 1 2 3
8In a _protected_fl 1 2 3
9In a _public_fl 1 2 3
10
11The a no arg constructor has been invoked
12In puba no arg constructor
13puba_priv_var is: 10 puba_prot_var is: 20 puba_pub_var is: 30
142 3
15
16In a _print 1 2 3
17In puba_public_fl
18puba_priv_var is: 10 puba_prot_var is: 20 puba_pub_var is: 30
192 3
20
21In a _public_fl 1 2 3
22In puba_private_fl
23puba_priv_var is: 10 puba_prot_var is: 20 puba_pub_var is: 30
242 3
25
26In puba_protected_fl
27puba_priv_var is: 10 puba_prot_var is: 20 puba_pub_var is: 30
282 3
29
30In puba_public_fl
31puba_priv_var is: 10 puba_prot_var is: 20 puba_pub_var is: 30
322 3
33
34In a _protected_fl 1 2 3
35In a _public_fl 1 2 3
```

```

1// priva.cpp
2
3#ifndef PRIVACPP
4#define PRIVACPP
5
6// this file introduces the class priva
7// it INHERITS from the class a
8// it inherits using the private inheritance mechanism
9// there are two types of inheritance, public and private
10
11// Inheritance means that an object of type priva is an object of type a AND some extra stuff
12
13
14
15
16
17
18
19
20
21
22
23
24// there are visibility issues in a derived class object
25#include <iostream.h>
26#include "base_a.cpp"
27// the class name is priva
28// it inherits from a
29// using the private mechanism
30class priva : private a
31{
32    private:
33        int priva_priv_var;           // private data field
34        void priva_private_fl();      // private member function
35    protected:
36        int priva_prot_var;           // protected data field
37        void priva_protected_fl();    // protected member function
38    public:
39        int priva_pub_var;             // public data field
40        void priva_public_fl();        // public member function
41        priva();                       // constructor
42        void priva_print();            // public member function
43        void priva_call_em();          // public member function
44};

```

```

1//this is the constructor for the derived class object
2//it should specify how it wants the construction of its base class portion to occur
3//it doesn't make this specification therefore the default no arg constructor is called
4
5priva::priva() : priva_priv_var(10), priva_prot_var(20), priva_pub_var(30)
6{
7    // before the first line in the derived class constructor is executed
8    // all the memory for the entire object has to be allocated
9    // since an object of type priva IS an object of type a AND some other
10   // stuff, the constructor for the a portion of priva object will be
11   // invoked before the first executable statement in this constructor
12   // is executed
13
14   // you will notice the print out from the a class constructor before
15   // the print out from this constructor
16   cout << "In priva no arg constructor \n";
17}
18
19// this is a private member function of the derived class
20// it has access to the public, protected and private data of the priva class
21// it has access to the public and protected variables of the a class
22// it DOES NOT have access to the private data of the a class
23void priva::priva_private_f1()
24{
25    cout << "In priva_private_f1 " << endl;
26    // examine accessability to the priva portion variables
27    cout << "priva_priv_var is: " // member functions may access private data of their own class
28    << priva_priv_var
29    << " priva_prot_var is: "
30    << priva_prot_var // member functions may access protected data of their own class
31    << " priva_pub_var is: "
32    << priva_pub_var // member functions may access public data of their own class
33    << endl;
34
35    // examine accessability to variables of base class
36    cout << "a_priv_var " // this variable is not visible, member functions of the derived
37    // class may not access private data of the base class
38    << a_prot_var // member functions of the derived class may access protected
39    // data of the base class
40    << " "
41    << a_pub_var // member functions of the derived class may access public
42    // data of the base class
43    << endl;
44}

```



```

1// this is a protected member function of the derived class
2// it has access to the public, protected and private data of the priva class
3// it has access to the public and protected variables of the base class a
4// it DOES NOT have access to the private data of the base class a
5void priva::priva_protected_f1()
6{
7    cout << "In priva_protected_f1 " << endl;
8    // examine accessability to variables of the priva portion
9    cout << "priva_priv_var is: "
10    << priva_priv_var
11    << " priva_prot_var is: "
12    << priva_prot_var
13    << " priva_pub_var is: "
14    << priva_pub_var
15    << endl;
16
17    // examine accessability to variables of base class
18    cout // << a_priv_var // this variable is not visible
19    << a_prot_var
20    << " "
21    << a_pub_var
22    << endl;
23}
24
25// this is a public member function of the derived class
26// it has access to the public, protected and private data of the priva class
27// it has access to the public and protected variables of the base class a
28// it DOES NOT have access to the private data of the base class a
29void priva::priva_public_f1()
30{
31    cout << "In priva_public_f1 " << endl;
32    // examine accessability of priva portion of the class variables
33    cout << "priva_priv_var is: "
34    << priva_priv_var
35    << " priva_prot_var is: "
36    << priva_prot_var
37    << " priva_pub_var is: "
38    << priva_pub_var
39    << endl;
40
41    // examine accessability to variables of base class
42    cout // << a_priv_var // this variable is not visible
43    << a_prot_var
44    << " "
45    << a_pub_var
46    << endl;
47}
48

```

```

1// this public member function has access to all three types of data that
2// are part of the priva portion of a priva object
3// it has access to the public and protected data of the base class portion
4// of the priva object
5// it DOES NOT have access to the private data of the base class portion
6// of the priva object
7void priva::priva_print()
8{
9    // from inside a member function, public, protected or private
10   // you can access the public, protected and private data elements
11   cout << "priva_priv_var is: "
12   << priva_priv_var
13   << " priva_prot_var is: "
14   << priva_prot_var
15   << " priva_pub_var is: "
16   << priva_pub_var
17   << endl;
18
19   cout << a_priv_var // this variable is not visible
20   << a_prot_var
21   << " "
22   << a_pub_var
23   << endl;
24}
25
26// this is a public member function
27// it can call the private, protected and public member functions of the
28//   priva portion of the priva class
29// it can call the protected and public member functions of the a portion, the base class portion
30//   of the priva class
31// it cannot call the private member functions of the a portion, the base class portion of the
32//   priva class
33void priva::priva_call_em()
34{
35   // from inside a member function, you can call any other member function of this class
36   this->priva_private_fl();
37   this->priva_protected_fl();
38   this->priva_public_fl();
39
40   // examine accessibility of functions in base class
41   // this->a_private_fl(); // this function is not visible
42   this->a_protected_fl(); // this function is visible
43   this->a_public_fl(); // this function is visible
44}
45#endif

```

```

1// privinht.cpp
2
3
4// this program exercises the class priva derived from the base class a
5// it uses private inheritance
6// because private inheritance is used, certain rules apply to what code
7// has access to the public, private and protected data and member functions
8// of the base class
9// the access rules for the derived class are also spelled out in this program
10
11USING PRIVATE INHERITANCE
12Member functions of the deriving class can access public and protected data and functions of the BASE
13class. Member functions of the deriving class cannot access private data or functions of the base class.
14Non member function code is the code that USERS of the class would write. Objects of the derived type,
15in non-member function code (i.e. main() ) MAY NOT access public functions of the base class. THIS is
16what separates Public from Private inheritance.
17
18// the base class has three areas to examine, public, protected, private
19// the derived class has three areas to examine, public, protected, private
20
21// there are three places we have to examine each of these three areas from:
22//   from within the code of a member function of the base class
23//   from within the code of a member function of the deriving class
24//   from outside the scope of any member function (i.e. in main)
25
26// The basic access rules are:
27//   Any member function can access any public, private or protected
28//       data element of its own class
29//   Any member function can access any public, private or protected
30//       member function of its own class
31
32//   No non member function code can access any private or protected
33//       data element of any class
34//   No non member function code can access any private or protected
35//       member function of any class
36
37//   Any non member function code can access any public data of any class directly
38//   Any non member function code can access any public function of any class directly
39
40//   No non member function code can access the public data of any class that serves as
41//       the base class for a class that derived PRIVATELY from it by using an instance of the
42//       derived class. However, that public data can be accessed directly through an instance of the
43//       Base class itself.

```

```

1#include <iostream.h>
2#include "base_a.cpp"
3#include "priva.cpp"
4
5main()
6{
7    // You can create an instance of a base class object
8    a obj1;
9    obj1.a_print();
10
11    // You can call the public member functions of the base class object
12    obj1.a_print();
13    obj1.a_public_fl();
14
15    // You cannot call the protected member functions from outside
16    // a member function of the class
17    // obj1.a_protected_fl();
18
19    // You cannot call the private member functions from outside
20    // a member function of the class
21    // obj1.a_private_fl();
22
23    // You can call a public member function that calls the
24    // public, protected and private member functions
25    obj1.a_call_em();
26
27    priva obj2;                // you can create an object of derived class
28    obj2.priva_print();        // we can call the public print function of the derived class
29    // obj2.a_print();         // we CANNOT call the public print function of the
30                                // base class via a derived class object
31                                // BECAUSE WE USED PRIVATE INHERITANCE
32
33    obj2.priva_public_fl();    // can call the public function of the priva portion of the class
34    // obj2.priva_protected_fl(); // protected function not visible
35    // obj2.priva_private_fl();  // private function not visible
36
37    // obj2.a_public_fl();       // CANNOT call the public function
38                                // of the base class portion of an object of type priva
39                                // via an instance of a priva object
40                                // we could call it directly via an instance of an a class object
41    // obj2.a_protected_fl();    // protected function not visible
42    // obj2.a_private_fl();      // private function not visible
43
44    obj2.priva_call_em();       // can call the public function of the
45                                // derived portion of the class

```

```

1      // examine accessibility of member variables of base object
2      // via an instance of the base object
3      // obj1.a_priv_var = 100;          // private variable is not visible
4      // obj1.a_prot_var = 100;         // protected variable is not visible
5      obj1.a_pub_var = 100;             // public data is visible
6
7      // examine accessibility of member variables of derived class portion
8      // of priva object via an instance of the derived object
9      // obj2.priva_priv_var = 200;      // private variable is not visible
10     // obj2.priva_prot_var = 200;      // protected variable is not visible
11     obj2.priva_pub_var = 200;         // public data is visible
12
13     // examine the accessibility of member variables of base portion of
14     // priva object via an instance of a derived object
15     // obj2.priva_priv_var = 300;      // variable is not visible
16     // obj2.priva_prot_var = 300;      // variable is not visible
17     obj2.priva_pub_var = 300;
18}

```

1Output From Running Program

2

3The a no arg constructor has been invoked

4In a _print 1 2 3

5In a _print 1 2 3

6In a _public_fl 1 2 3

7In a _private_fl 1 2 3

8In a _protected_fl 1 2 3

9In a _public_fl 1 2 3

10

11The a no arg constructor has been invoked

12In priva no arg constructor

13priva_priv_var is: 10 priva_prot_var is: 20 priva_pub_var is: 30

142 3

15

16In priva_public_fl

17priva_priv_var is: 10 priva_prot_var is: 20 priva_pub_var is: 30

182 3

19

20In priva_private_fl

21priva_priv_var is: 10 priva_prot_var is: 20 priva_pub_var is: 30

222 3

23

24In priva_protected_fl

25priva_priv_var is: 10 priva_prot_var is: 20 priva_pub_var is: 30

262 3

27

28In priva_public_fl

29priva_priv_var is: 10 priva_prot_var is: 20 priva_pub_var is: 30

302 3

31

32In a _protected_fl 1 2 3

33In a _public_fl 1 2 3

34

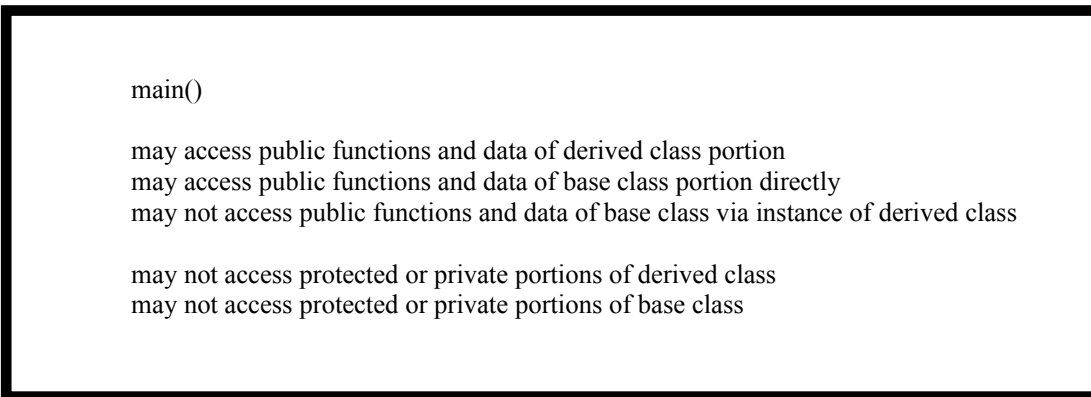
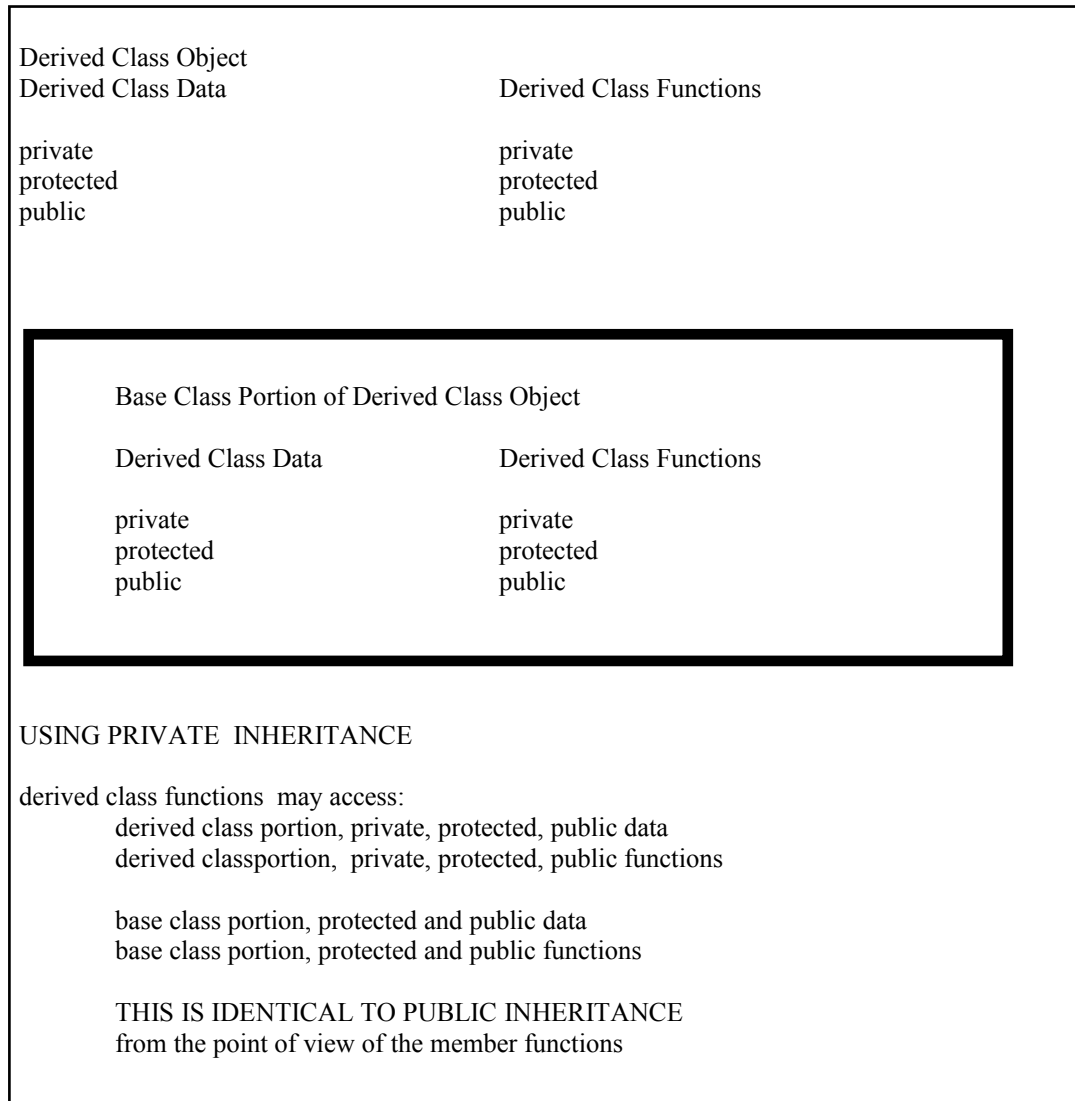
35So, in a nutshell, private inheritance is more restrictive than public inheritance to the end user of the class

36because it hides the public portion of the base class from the user of the derived class when attempting to

37access the base class via an instance of the derived class.

1 Private Inheritance Diagram

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1// polyinh1.cpp

```
2// this program illustrates that a deriving class can redefine a function
3// that is defined in the base class, this is due to a feature of the compiler known as complete
4// function name resolution. Although a function call may look as simple as f1()
5// to the compiler it looks like class_membership::f1()
6#include <iostream.h>
7
8class b
9{
10    private:
11        int var1;
12    public:
13        b();                // no arg constructor
14        void set_var1(int);  // will not be overloaded
15        int get_var1(void);  // will not be overloaded
16
17        // this function is going to be redefined in the class
18        // that inherits from class b, the question then will be;
19        // in code that calls manipulate_var1, which function will
20        // be called, the base class function or the derived class
21        // function??
22        void manipulate_var1(int); // do something to var1
23Notice that nothing special or different is done to the function manipulate_var1. Nothing different is done
24to a function that is going to be overloaded. No designer of a function could anticipate which of their
25functions are going to be overloaded. You may have a pretty good idea, but you can't be sure. When you
26are sure, then you will have access to another feature of inheritance called virtuality, which is discussed in
27later programs. But for now, let's see how to deal with functions that are overloaded by the designer of the
28deriving classes.
29};
30
31b::b() : var1(10)
32{
33    cout << "In b no arg constructor \n";
34}
35
36void b::set_var1(int ivar1)
37{    // would do error checking here
38    var1 = ivar1;
39}
40
41int b::get_var1()
42{
43    return(var1);
44}
45// this function is called when the invoking object is of type class b
46void b::manipulate_var1(int ix)
47{
48    // could do error checking here
49    cout << "In base class manipulate_var1, multiplying "
50    << var1 << " by " << ix << endl;
51    var1 *= ix;
52}
```



```

1// the class pubb is an object of type b AND the additional fields var2 and the additional functions
2// pubb, set_var2, get_var2, and manipulate_var1
3// // notice that manipulate_var1 has the same name and argument list as manipulate_var1 in the base
4// class portion. The question then is how can the compiler or run time system decide which version
5// of manipulate_var1 is to be called. Up until now we have said functions can have the same name as
6// long as they have a different argument list. Here we have the same name and the same argument list
7// the Compiler needs to decide whether you mean    b::manipulate_var1(int)    or
8//                                                    pubb::manipulate_var1(int)
9// the compiler decides based on the data type of the invoking object
10// if manipulate_var1() is called via            instance_of_base.manipulate_var1()
11// then    b::manipulate_var1 is called
12// if manipulate_var1() is called via            instance_of_derived.manipulate_var1()
13// then    pubb::manipulate_var1 is called
14
15class pubb : public b
16{
17    private:
18        int var2;
19    public:
20        pubb();                // no arg constructor
21        void manipulate_var1(int);    // OVERLOADED FUNCTION
22                                    // SAME FUNCTION EXISTS IN BASE CLASS
23        void set_var2(int);        // new function unique to pubb
24        int get_var2(void);
25};
26
27pubb::pubb() : var2(5)
28{
29    cout << "In pubb no arg constructor \n";
30}
31
32void pubb::set_var2(int ivar2)
33{
34    var2 = ivar2;
35}
36
37int pubb::get_var2()
38{
39    return(var2);
40}
41
42// this is the overloaded function
43// it is called when the invoking object is of type pubb
44void pubb::manipulate_var1(int ix)
45{
46    cout << "In derived class manipulate_var1, adding"
47    << ix << " to " << this->get_var1() << endl
48    << "multiplying "
49    << var2 << " by " << 2 << endl;
50
51    this->set_var1( this->get_var1() + ix);
52    var2 *= 2;
53}

```

```

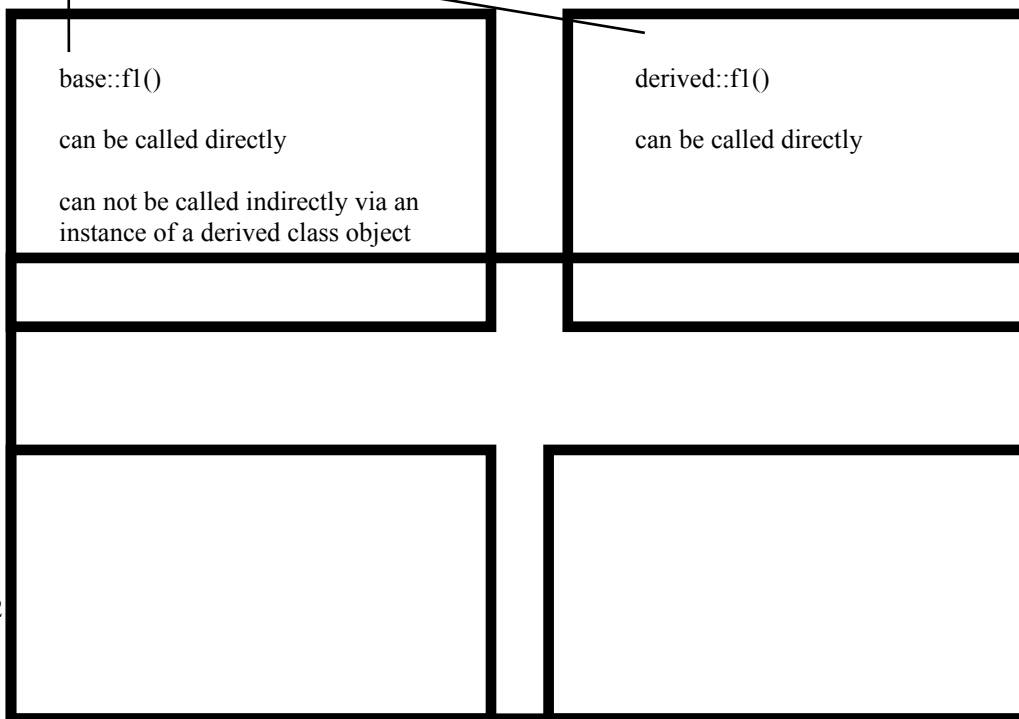
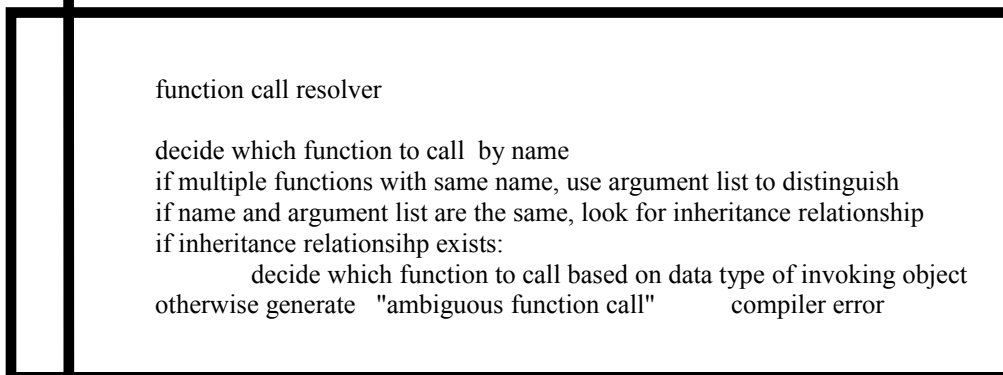
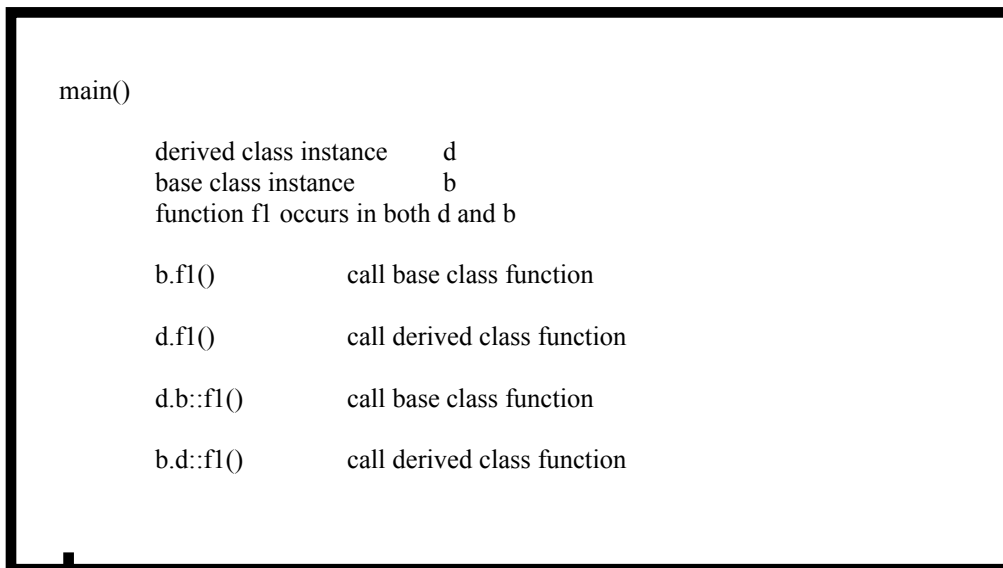
1main()
2{
3    // declare an object of the base type
4    b obj1;
5
6    // make calls to the base class functions
7    cout << "Initial value of obj1.var1 is " << obj1.get_var1() << endl;
8    obj1.set_var1(53);
9    cout << "New    value of obj1.var1 is " << obj1.get_var1() << endl;
10   obj1.manipulate_var1(2);           // base class function called
11   cout << "New    value of obj1.var1 is " << obj1.get_var1() << endl;
12
13   // declare an object of the derived type
14   pubb obj2;
15
16   // make calls to the derived class functions
17   cout << "\nInitial value of obj2.var1 is " << obj2.get_var1() << endl;
18   cout << "Initial value of obj2.var2 is " << obj2.get_var2() << endl;
19
20   cout << "Calling obj2.set_var1(7) and obj2.set_var2(17)\n";
21   obj2.set_var1(7);
22   obj2.set_var2(17);
23   cout << "New    value of obj2.var1 is " << obj2.get_var1() << endl;
24   cout << "New    value of obj2.var2 is " << obj2.get_var2() << endl;
25
26   // Which manipulate_var1 will be called? Derived or Base?
27   cout << "\nCalling manipulate_var1 via obj2.manipulate_var1(2) \n";
28   obj2.manipulate_var1(2);           // derived class function is called
29   cout << "New    value of obj2.var1 is " << obj2.get_var1() << endl;
30   cout << "New    value of obj2.var2 is " << obj2.get_var2() << endl;
31
32   // force call to the base class functions
33   cout << "\nCalling manipulate_var1 via obj2.b::manipulate_var1(2) \n";
34   obj2.b::manipulate_var1(3);       // base class function called because of name forcing
35   cout << "New values for obj2 are " <<
36   obj2.get_var1() << " " <<
37   obj2.get_var2() << endl;
38}

```

```
1Output From Running Program
2
3In b no arg constructor
4Initial value of obj1.var1 is 10
5New    value of obj1.var1 is 53
6In base class manipulate_var1, multiplying 53 by 2
7New    value of obj1.var1 is 106
8In b no arg constructor
9In pubb no arg constructor
10
11Initial value of obj2.var1 is 10
12Initial value of obj2.var2 is 5
13Calling obj2.set_var1(7) and obj2.set_var2(17)
14New    value of obj2.var1 is 7
15New    value of obj2.var2 is 17
16
17Calling manipulate_var1 via obj2.manipulate_var1(2)
18In derived class manipulate_var1, adding2 to 7
19multiplying 17 by 2
20New    value of obj2.var1 is 9
21New    value of obj2.var2 is 34
22
23Calling manipulate_var1 via obj2.b::manipulate_var1(2)
24In base class manipulate_var1, multiplying 9 by 3
25New values for obj2 are 27 34
```

Polymorphism of Functions In Inheritance Relationship Diagram

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1Section7.doc

2

3Inheritance leads to some very powerful possibilities in the C++ programming language. Virtual functions
4allow us to utilize late binding which allows us to implement polymorphic data structures.

5A polymorphic data structure is a data structure that can hold objects of different types.

6

7For example, how would you like to have an array that could hold cars and trucks and any other type of
8vehicle you ever dreamed of. Cars and trucks are different data types, however, a polymorphic data
9structure, through the magic of late binding, can make a truly powerful data structure.

10

11I call late binding and virtual functions and polymorphic data structures the general purpose car wash.

12When you go the car wash, is there a car wash for small cars, a car wash for mid sized cars, a car wash for
13small trucks, a car wash for full sized cars, a car wash for jeeps, and so on???

14NO!

15There is a car wash for four wheeled vehicles.

16How can the car wash designers get away with this?

17It's because of that orange rubber thing that grabs your left front tire.

18The car wash knows that all VEHICLES are going to have a left front tire that is between this width and
19that width and as long as they recognize that fact who cares what the rest of the car looks like.

20

21We are used to polymorphism in our every day lives, it's time we started getting polymorphism into our
22programming languages.

23

24Late Binding

25Virtual Functions

26Deep Hierarchies

27Multiple Chains of Virtuality.

28p2bp2d.cpp

polymorphism, pointers and late binding

29

30p2bp2d1.cpp

polymorphism, pointers and late binding

31

32p2bp2d2.cpp

virtual functions

33

34p2bp2d3.cpp

3 deep chain of virtuality and late binding

35

36name.h name.cpp

class definition for a human name

37drv_name.cpp

program to exercise name class

38

39address.h address.cpp

class definition for a human address

40drv_addr.cpp

program to exercise address class

41

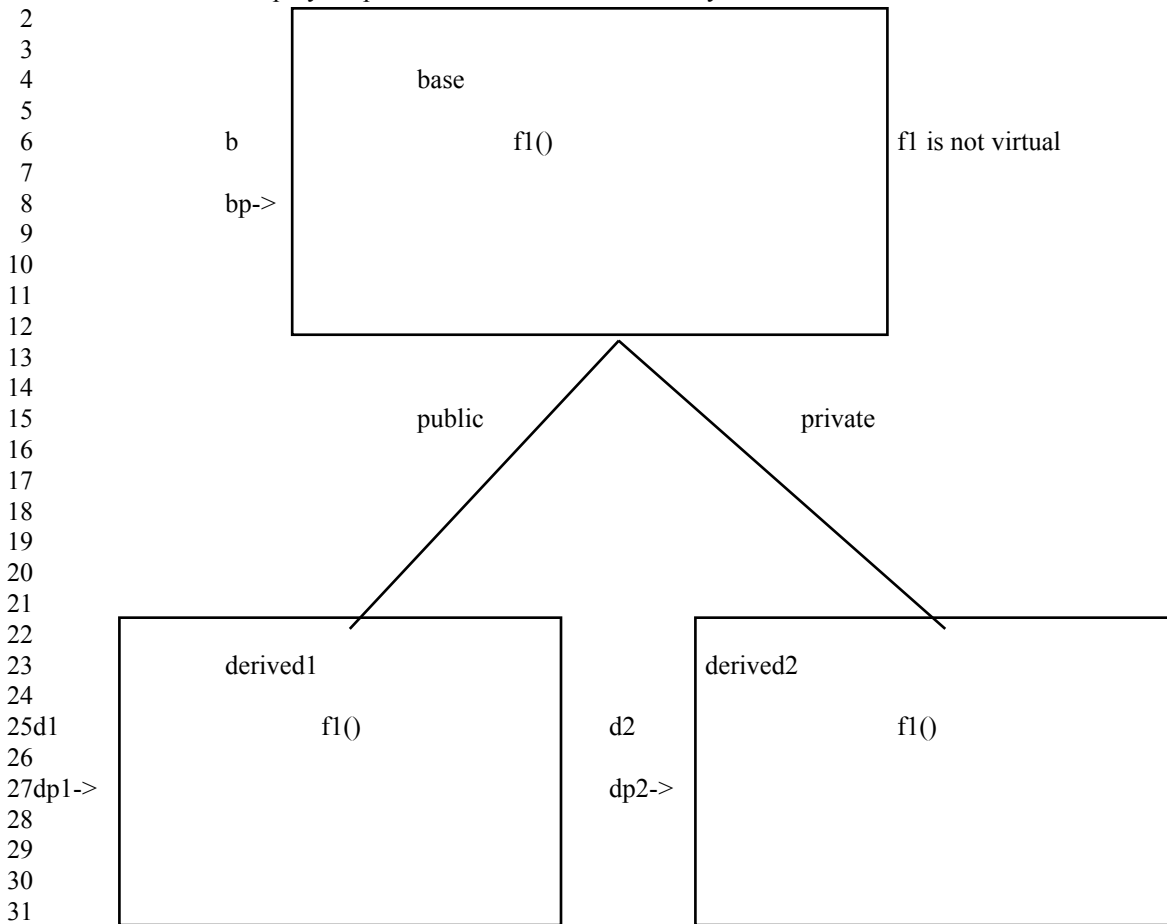
42

43polyarray.cpp

program that demonstrates polymorphic arrays and virtual functions
in action.

44

1Examine the issues of polymorphism in an inheritance hierarchy. f1 is in base and derived classes



33Code	Function That Is Called
34b.f1();	base f1
35bp = &b;	
36bp->f1();	base f1
37	
38d1.f1();	derived f1
39dp1 = &d1;	
40dp1->f1()	derived f1
41	
42d2.f1();	derived f1
43dp2 = &d2;	
44dp2->f1();	derived f1
45	
46bp = &d1;	
47bp->f1();	base class f1
48bp = &d2;	
49bp->f1();	base class f1

```

1// pointer_to_base__pointer_to_derived.C
2// p2bp2d.cpp
3#if 0
4
5When you have a base class and 1 or more classes derived from that base
6class, in either a flat hierarchy or a deep hierarchy, you can implement very
7powerful and extremely useful data structures built on two features of C++:
8    Variables of type pointer to base class may hold the address of
9        either a base class object or any object of a class derived
10       from that base class
11    If there is a polymorphic function shared between the base class and
12        the derived class, then which function is called can be
13        determined either at compile time OR at run time.
14    When it is determined is based on whether the polymorphic
15        function has been declared VIRTUAL in the base class or not
16        AND based on whether the polymorphic function is called
17        using an object of a certain type or a pointer to a certain
18        type. There are many possibilities, the subsequent programs
19        hopefully illustrate all the confusing yet infinitely valuable possibilities.
20
21In this program there is a base class and two derived classes.
22One class derives publicly, the other derives privately.
23There is a function f1 in the base class
24There is a function f1 in each of the derived classes
25
26If we call f1 using an instance of an object then we know which f1
27will be called. The function call will be determined at compile time by the
28data type of the bound object.
29
30But what if we aren't calling f1 using a bound object?
31
32What if we are calling f1 using a pointer mechanism?
33Will which function to call be determined by using the data type of the pointer
34or the data type of the object being pointed to?
35This program and the two which follow demonstrate the answer.
36

```

1 Which function is called is determined first by the data type of the bound
2 object. If the type of the bound object is known and is not a pointer, then
3 static binding is employed.

4

5 If the bound object is a pointer there are two situations:

6 1. the pointer holds the address of an object of the "proper" type

7 where proper is either base or derived

8 i.e. the pointer is of type pointer to base and the address

9 stored is the address of a base class object or the pointer is

10 of type pointer to derived and the address stored is the

11 address of a derived class object

12

13 2. the pointer holds the address of an object of a "derived" type

14 i.e. the pointer is of type pointer to base but the address

15 stored is the address of a derived class object

16

17 In this case, if the base class function is NOT VIRTUAL

18 then the base class function is called, regardless of the data type of

19 the object being pointed to because of the data type of the pointer.

20

21 if the base class function is VIRTUAL

22 then the base class or derived class function is called based on the

23 data type of the object being pointed to, not the data type of the

24 pointer. This is called DYNAMIC BINDING.

25

26 This program does not use virtual functions

27 it shows how non virtual functions will always revert to the base class function

28 if a base class pointer is used because of the data type of the pointer

29 #endif

30

31 #include <iostream.h>

32 class base

33 {

34 private:

35 int x;

36 public:

37 void f1() { cout << "In base::f1\n"; }

38 };

39

40 class derived1 : public base

41 {

42 private:

43 int y;

44 public:

45 void f1() { cout << "In derived1::f1\n"; }

46 };

47

48 class derived2 : private base

49 {

50 private:

51 int y;

52 public:

53 void f1() { cout << "In derived2::f1\n"; }

54 };


```

1main()
2{
3    // these allocations and assignments make sense
4    // we are putting addresses of objects that are of the type
5    // that the pointer is supposed to point to
6    base b;           // base class object
7    base * bp = &b;   // pointer to base with address of base object
8
9    // call the function f1 that is in the base class
10   // the compiler knows which one to call based on the data type of the
11   // invoking object b
12   cout << "Calling b.f1() ";
13   b.f1();
14   // in this call the compiler knows which function to call based on
15   // the data type of the pointer, pointer to base
16   cout << "Calling bp->f1() with address of base object b ";
17   bp->f1();
18   cout << endl;
19
20   derived1 d1;
21   derived1 * dp1 = &d1; // derived, pointer to derived
22
23   // call the function f1 that is in the derived class
24   // the compiler knows which one to call based on the data type of the
25   // invoking object
26   cout << "Calling d1.f1() ";
27   d1.f1();
28   // in this call the compiler knows which function to call based on
29   // the data type of the pointer, pointer to derived
30   cout << "Calling dp1->f1() with address of derived object d1 ";
31   dp1->f1();
32   cout << endl;
33
34
35   derived2 d2;
36   derived2 * dp2 = &d2; // derived, pointer to derived
37
38   // call the function f1 that is in the base class
39   // the compiler knows which one to call based on the data type of the
40   // invoking object
41   cout << "Calling d2.f1() ";
42   d2.f1();
43   // in this call the compiler knows which function to call based on
44   // the data type of the pointer, pointer to derived
45   cout << "Calling dp2->f1() with address of derived object d2 ";
46   dp2->f1();
47   cout << endl;

```

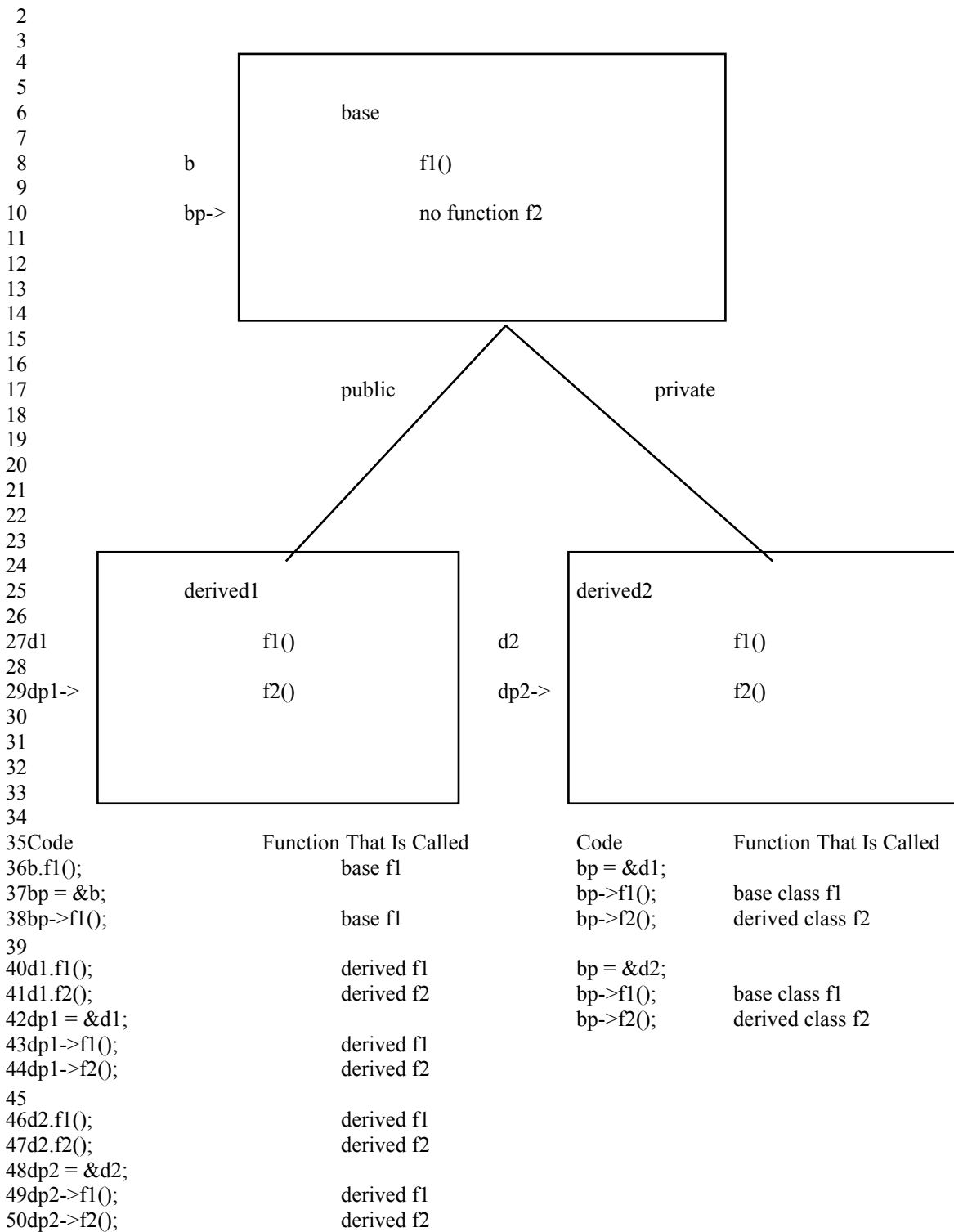
```

1 // assign a derived address to a pointer to base class object
2 bp = &d1;
3 cout << "Calling bp->f1() with address of derived object d1 ";
4 bp->f1(); // which function will get called, base or derived?
5 // the base class function is called because of the data type of the
6 // pointer, IF THE FUNCTION F1 WERE VIRTUAL, the derived function
7 // would have been called
8
9 // bp = &d2; // cannot assign address of privately derived object
10 // to a pointer to base because of the private
11 // derivation
12 // In a later program we will attempt to resolve
13 // this problem
14 // bp->f1(); // which function will get called, base or derived?
15
16 // now try to make an array of pointers to base and populate it with
17 // addresses of both base and derived objects
18 // this works. It is called a POLYMORPHIC data structure
19 // the next program illustrates an outstanding usage of this structure
20 base * barray[4];
21
22 barray[0] = bp;
23 barray[1] = dp1;
24
25 // this line won't work because of the private derivation
26 // barray[2] = dp2;
27
28 cout << "Calling barray[0]->f1() ";
29 barray[0]->f1();
30 cout << endl;
31 cout << "Calling barray[1]->f1() ";
32 barray[1]->f1();
33 cout << endl << endl;
34}

```

```
1Output From Running Program
2
3Calling b.fl() In base::fl
4Calling bp->fl() with address of base object b In base::fl
5
6Calling d1.fl() In derived1::fl
7Calling dp1->fl() with address of derived object d1 In derived1::fl
8
9Calling d2.fl() In derived2::fl
10Calling dp2->fl() with address of derived object d2 In derived2::fl
11
12Calling bp->fl() with address of derived object d1 In base::fl
13Calling barray[0]->fl() In base::fl
14
15Calling barray[1]->fl() In base::fl
16
17
18
```

1Examine "bottom of hierarchy only" functions. f2 is only in the deriving classes, not the base class



```

1// pointer_to_base__pointer_to_derived1.C
2// p2bp2d1.cpp
3
4
5// this program extends pointer_to_base__pointer_to_derived.C by adding a
6// function f2 to the derived classes. There is no function f2 in the base
7// class. The question then becomes, can f2 be called using the pointer
8// methods that were employed to call f1 in the previous program?
9
10// The answer is yes.
11// Since f2 is not polymorphic on a base class function, the call will resolve
12// to the derived class object
13// Furthermore, calls to f2 cannot be made using a pointer to base class object
14// even if it holds the address of a derived class object because static
15// binding is used because the functions are still not declared VIRTUAL
16
17#include <iostream.h>
18
19class base
20{
21    private:
22        int x;
23    public:
24        void f1() { cout << "In base::f1\n";}
25};
26
27class derived1 : public base
28{
29    private:
30        int y;
31    public:
32        void f1() { cout << "In derived1::f1\n"; }
33        void f2() { cout << "In derived1::f2\n"; }
34};
35
36class derived2 : private base
37{
38    private:
39        int y;
40    public:
41        void f1() { cout << "In derived2::f1\n"; }
42        void f2() { cout << "In derived2::f2\n"; }
43};

```

```

1main()
2{
3    base b;                // base class object
4    base * bp = &b;        // pointer to base with address of base object
5
6    cout << "Calling b.f1() ";
7    b.f1();
8    // b.f2();              // there is no f2 function in the base class
9    cout << "Calling bp->f1() with address of base object b ";
10   bp->f1();
11   // bp->f2();             // there is no f2 function in base class
12   cout << endl;
13
14
15   derived1 d1;
16   derived1 * dp1 = &d1;   // derived, pointer to derived
17
18   cout << "Calling d1.f1() ";
19   d1.f1();                // the derived f1 is called
20   cout << "Calling d1.f2() ";
21   d1.f2();                // the derived f2 is called
22   cout << "Calling dp1->f1() with address of derived object d1 ";
23   dp1->f1();              // the derived f1 is called because dp1 is of type
24                           // pointer to derived
25   cout << "Calling dp1->f2() with address of derived object d1 ";
26   dp1->f2();              // the derived f2 is called because dp1 is of type
27                           // pointer to derived
28   cout << endl;
29
30
31   derived2 d2;
32   derived2 * dp2 = &d2;   // derived, pointer to derived
33
34   // call the function f1 that is in the base class
35   // the compiler knows which one to call based on the data type of the
36   // invoking object or the data type of the pointer
37   cout << "Calling d2.f1() ";
38   d2.f1();                // derived f1 called because d2 is of type derived
39   cout << "Calling d2.f2() ";
40   d2.f2();                // derived f2 is called because d2 is of type derived
41   cout << "Calling dp2->f1() with address of derived object d2 ";
42   dp2->f1();              // derived f1 called, dp2 of type pointer to derived
43   cout << "Calling dp2->f2() with address of derived object d2 ";
44   dp2->f2();              // derived f2 called, dp2 of type pointer to derived
45   cout << endl;

```

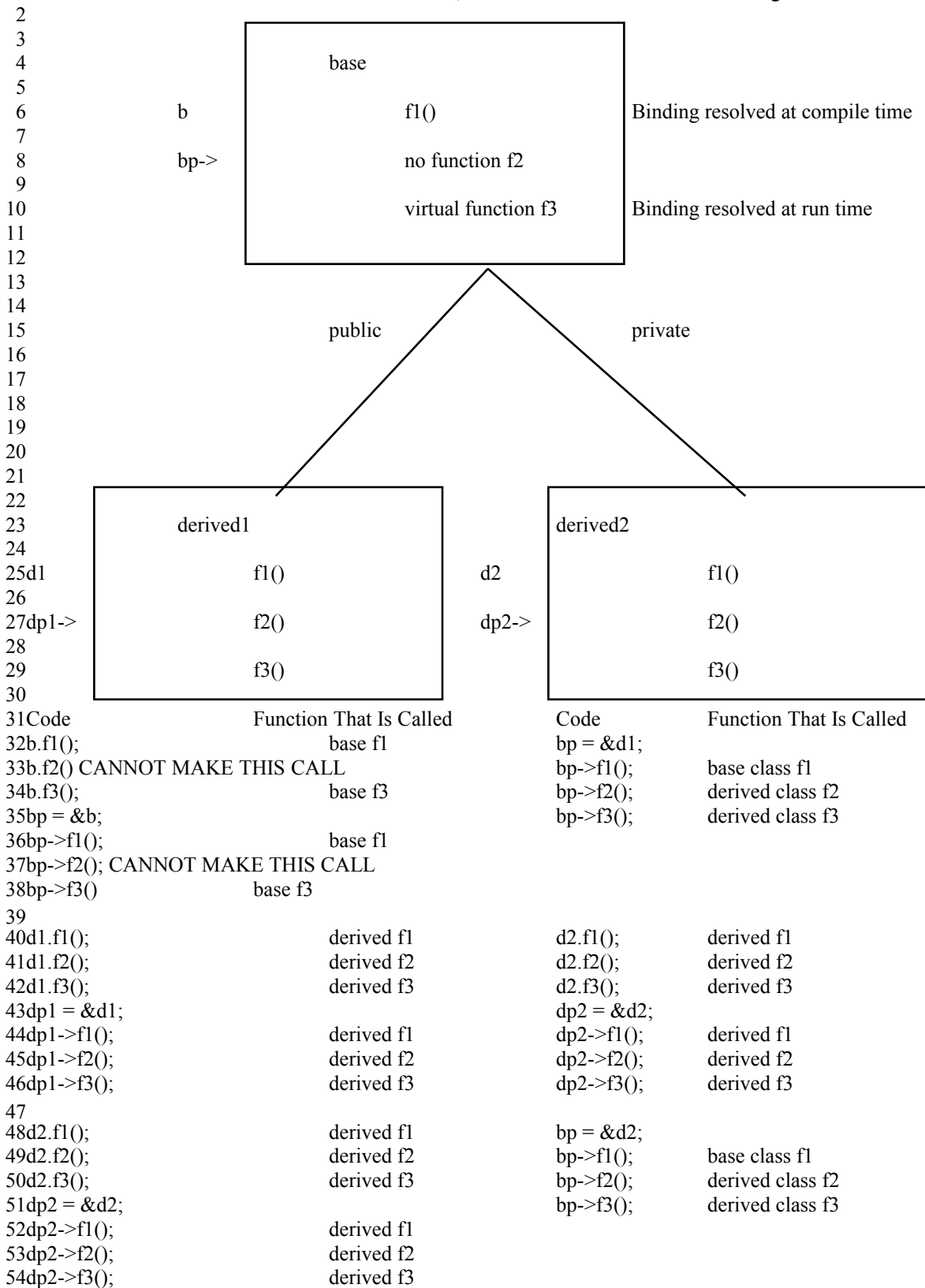
```

1 // assign the address of a derived object to a variable of type pointer
2 // to base
3 bp = &d1;
4 cout << "Calling bp->f1() with address of derived object d1 ";
5 bp->f1(); // which function will get called, base or derived?
6 // the base function is called because f1 is not
7 // VIRTUAL and bp is of type pointer to base
8
9 // bp->f2(); // there is no base class function f2 and bp is of
10 // type pointer to base
11
12 // bp = &d2; // can't do this assignment because private derivation
13 // bp->f1(); // can't do this call
14 // bp->f2(); // can't do this call
15
16 // now try to make an array of pointers to base and populate it with
17 // addresses of both base and derived objects
18 // this works. It is called a POLYMORPHIC data structure
19 // the next program illustrates an outstanding usage of this structure
20 base * barray[4];
21
22 barray[0] = bp;
23 barray[1] = dp1;
24
25 // this line won't work because of the private derivation
26 // barray[2] = dp2;
27
28 cout << "Calling barray[0]->f1() ";
29 barray[0]->f1();
30 cout << endl;
31 cout << "Calling barray[1]->f1() "; // will the base or derived be called?
32 barray[1]->f1();
33
34 // cout << "Calling barray[1]->f2() "; // will the derived be accessible?
35 // barray[1]->f2(); // NO
36 cout << endl << endl;
37}

```

```
1Output From Running Program
2
3Calling b.f1() In base::f1
4Calling bp->f1() with address of base object b In base::f1
5
6Calling d1.f1() In derived1::f1
7Calling d1.f2() In derived1::f2
8Calling dp1->f1() with address of derived object d1 In derived1::f1
9Calling dp1->f2() with address of derived object d1 In derived1::f2
10
11Calling d2.f1() In derived2::f1
12Calling d2.f2() In derived2::f2
13Calling dp2->f1() with address of derived object d2 In derived2::f1
14Calling dp2->f2() with address of derived object d2 In derived2::f2
15
16Calling bp->f1() with address of derived object d1 In base::f1
17Calling barray[0]->f1() In base::f1
18
19Calling barray[1]->f1() In base::f1
20
21
22
```


1Examine Virtual Functions. f3 is a virtual function, it is in the base class and the deriving classes.



```

1// pointer_to_base__pointer_to_derived2.C
2// p2bp2d2.cpp
3
4// this program extends pointer_to_base__pointer_to_derived1.C by adding a
5// function f3 to the derived classes. There is a function f3 in the base
6// class and it has been declared to be VIRTUAL. The question then
7// becomes, can f3 be called using the pointer methods that were employed to
8// call f1 in the previous program and if so, which function f3 will be called,
9// the base or derived function class function?
10
11// VIRTUAL functions cause DYNAMIC binding to be used to determine which function
12// to call. That means, that the function call will not be resolved at compile
13// time based on the data type of the invoking object or the data type of
14// the pointer used to do the invocation but rather at run time
15// based on the data type of the invoking object or the data type of the
16// address stored in a pointer REGARDLESS OF THE DATA TYPE OF THE POINTER
17
18#include <iostream.h>
19
20class base
21{
22    private:
23        int x;
24    public:
25        void f1() { cout << "In base::f1\n"; }
26        virtual void f3() { cout << "In base::f3\n"; }
27};
28
29class derived1 : public base
30{
31    private:
32        int y;
33    public:
34        void f1() { cout << "In derived1::f1\n"; }
35        void f2() { cout << "In derived1::f2\n"; }
36        void f3() { cout << "In derived1::f3\n"; }
37};
38
39class derived2 : private base
40{
41    private:
42        int y;
43    public:
44        void f1() { cout << "In derived2::f1\n"; }
45        void f2() { cout << "In derived2::f2\n"; }
46        void f3() { cout << "In derived2::f3\n"; }
47};

```

```

1main()
2{
3    base b;
4    base * bp = & b;          // base, pointer to base
5
6    cout << "Calling b.f1() ";
7    b.f1();
8    // b.f2();                // there is no f2 in base class objects
9    cout << "Calling b.f3() ";
10   b.f3();
11   cout << "Calling bp->f1() with address of base object b ";
12   bp->f1();
13   // bp->f2();                // there is no f2 in base class objects
14   cout << "Calling bp->f3() with address of base object b ";
15   bp->f3();
16   cout << endl;
17
18   derived1 d1;
19   derived1 * dp1 = & d1;    // derived, pointer to derived
20
21   cout << "Calling d1.f1() ";
22   d1.f1();                  // derived class object called, d1 determines
23   cout << "Calling d1.f2() ";
24   d1.f2();                  // derived class object called, d1 determines
25   cout << "Calling d1.f3() ";
26   d1.f3();                  // derived class object called, d1 determines
27   cout << "Calling dp1->f1() with address of derived object d1 ";
28   dp1->f1();                 // derived class object called, dp1 determines
29   cout << "Calling dp1->f2() with address of derived object d1 ";
30   dp1->f2();                 // derived class object called, dp1 determines
31   cout << "Calling dp1->f3() with address of derived object d1 ";
32   dp1->f3();                 // derived class object called, dp1 determines
33   cout << endl;
34
35
36   derived2 d2;
37   derived2 * dp2 = & d2;    // derived, pointer to derived
38
39   // call the function f1 that is in the base class
40   // the compiler knows which one to call based on the data type of the
41   // invoking object or the data type of the pointer
42   cout << "Calling d2.f1() ";
43   d2.f1();                  // derived class object called, d2 determines
44   cout << "Calling d2.f2() ";
45   d2.f2();                  // derived class object called, d2 determines
46   cout << "Calling d2.f3() ";
47   d2.f3();                  // derived class object called, d2 determines
48   cout << "Calling dp2->f1() with address of derived object d2 ";
49   dp2->f1();                 // derived class object called, dp2 determines
50   cout << "Calling dp2->f2() with address of derived object d2 ";
51   dp2->f2();                 // derived class object called, dp2 determines
52   cout << "Calling dp2->f3() with address of derived object d2 ";
53   dp2->f3();                 // derived class object called, dp2 determines
54   cout << endl;

```

```

1      // assign the address of a derived object to a variable of type pointer
2      // to base
3      bp = &d1;
4      cout << "Calling bp->f1() with address of derived object d1 ";
5      bp->f1();           // base called, bp determines
6      cout << "Calling bp->f3() ";
7      bp->f3();           // DERIVED called, address stored in bp determines
8                          // because f3 is VIRTUAL
9
10     base * barray[4];
11     barray[0] = bp;
12     barray[1] = dp1;
13
14     cout << "Calling barray[0]->f1() ";
15     barray[0]->f1();
16     cout << endl;
17
18     cout << "Calling barray[1]->f1();           // base called. why?
19     barray[1]->f1();
20     // cout << "Calling barray[1]->f2() ";       // can't make this call
21     //barray[1]->f2();                           // can't make this call
22     cout << "Calling barray[1]->f3() ";         // DERIVED CALLED. WHY?
23     barray[1]->f3();
24     cout << endl << endl;
25}

```

1Output From Running Program

2

3Calling b.f1() In base::f1

4Calling b.f3() In base::f3

5Calling bp->f1() with address of base object b In base::f1

6Calling bp->f3() with address of base object b In base::f3

7

8Calling d1.f1() In derived1::f1

9Calling d1.f2() In derived1::f2

10Calling d1.f3() In derived1::f3

11Calling dp1->f1() with address of derived object d1 In derived1::f1

12Calling dp1->f2() with address of derived object d1 In derived1::f2

13Calling dp1->f3() with address of derived object d1 In derived1::f3

14

15Calling d2.f1() In derived2::f1

16Calling d2.f2() In derived2::f2

17Calling d2.f3() In derived2::f3

18Calling dp2->f1() with address of derived object d2 In derived2::f1

19Calling dp2->f2() with address of derived object d2 In derived2::f2

20Calling dp2->f3() with address of derived object d2 In derived2::f3

21

22Calling bp->f1() with address of derived object d1 In base::f1

23Calling bp->f3() In derived1::f3

24Calling barray[0]->f1() In base::f1

25

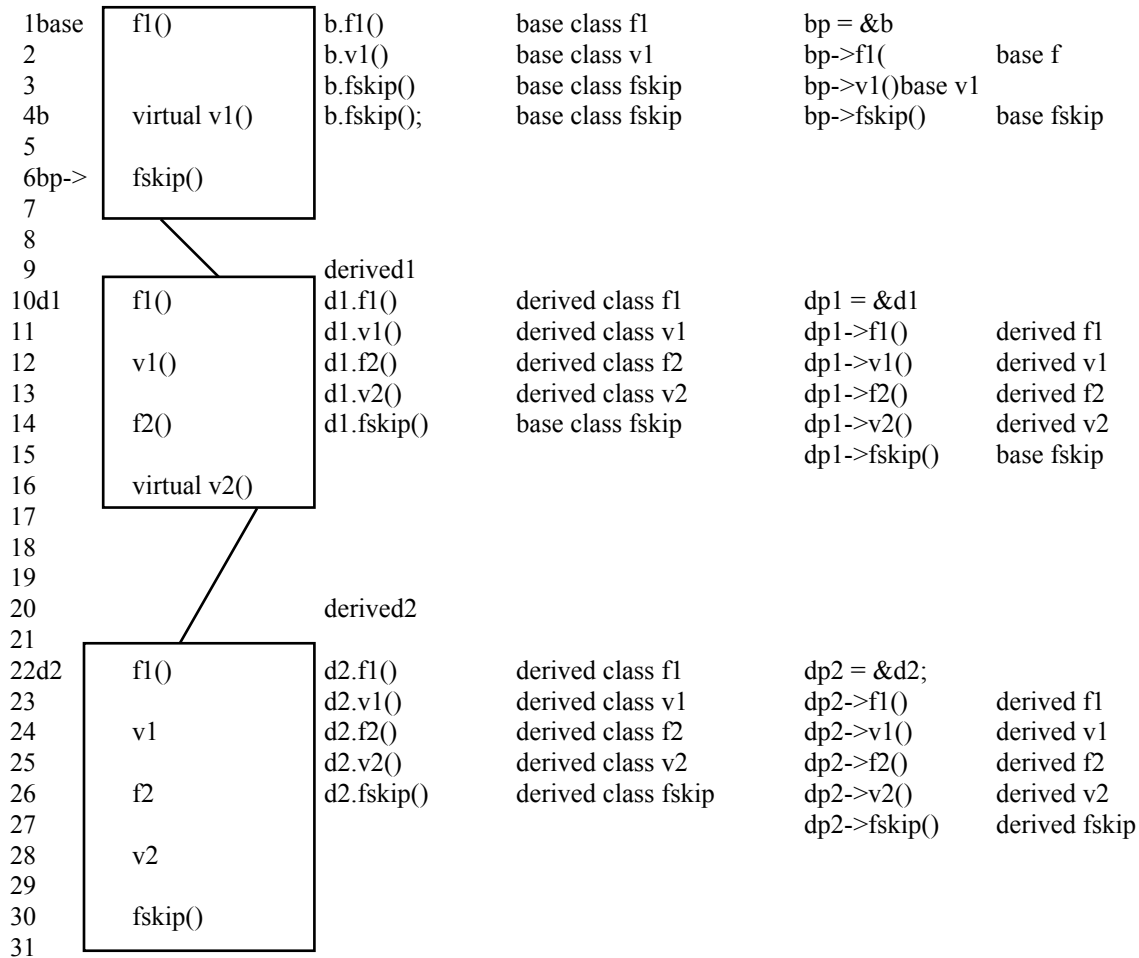
26Calling barray[1]->f1() In base::f1

27Calling barray[1]->f3() In derived1::f3

28

29

30



32 NOW THESE ARE THE INTERESTING CALLS

```

33 bp = &d1;          base class pointer with address of derived object
34 bp->f1()           base class f1
35 bp->v1()           derived class v1
36 bp->fskip()        base class fskip
37 bp->f2()           CANNOT MAKE THIS CALL
38 bp->v2()           CANNOT MAKE THIS CALL
39
40 bp = &d2;          base class pointer with address of object that inherited
41                      from the base class
42 bp->f1();          base class f1
43 bp->v2()           derived 2 v2
44 bp->fskip()        base class fskip
45 bp->f2()           CANNOT MAKE THIS CALL
46 bp->v2()           CANNOT MAKE THIS CALL
47
48 dp1 = &d2;         pointer to class derived from base with address of object derived from derived class
49 dp1->f1()          derived 1 f1
50 dp1->v1()          derived 2 v1
51 dp1->fskip()       base class fskip
52 dp1->f2()          derived 1 f2
53 dp1->v2()          derived 2 v2

```

```

1// pointer_to_base__pointer_to_derived3.C
2// p2bp2d3.cpp
3
4// this program illustrates virtual functions in a deep hierarchy
5#include <iostream.h>
6
7class base
8{
9    private:
10        int x;
11    public:
12        void f1() { cout << "In base::f1\n"; }
13        virtual void v1() { cout << "In base::v1\n"; }
14
15        void fskip() { cout << "In base::fskip\n"; }
16};
17
18class derived1 : public base
19{
20    private:
21        int y;
22    public:
23        void f1() { cout << "In derived1::f1\n"; }
24        void v1() { cout << "In derived1::v1\n"; }
25
26        // there is no f2 in base class
27        // there is no v2 in base class
28
29        // these two functions form a "terminus of function chains"
30        // in the case of v2, a new "terminus of virtuality"
31        void f2() { cout << "In derived1::f2\n"; }
32        virtual void v2() { cout << "In derived1::v2\n"; }
33
34        // notice that this class does not redefine fskip
35};
36
37// this class derives from derived1, not directly from base
38class derived2 : public derived1
39{
40    private:
41        int y;
42    public:
43        void f1() { cout << "In derived2::f1\n"; }
44        void v1() { cout << "In derived2::v1\n"; }
45
46        void f2() { cout << "In derived2::f2\n"; }
47        void v2() { cout << "In derived2::v2\n"; }
48
49        void fskip() { cout << "In derived2::fskip\n"; }
50};

```

```

1main()
2{
3    base b;
4    base * bp = & b;          // base, pointer to base
5
6    // these calls illustrate the straight forward calls using a known object
7    cout << "\nCalling b.f1() ";
8    b.f1();
9    cout << "Calling b.v1() ";
10   b.v1();
11   cout << "Calling b.fskip() ";
12   b.fskip();
13
14   // and a pointer of type pointer to base holding the address
15   // of an object of type pointer to base
16   cout << "\nHave assigned address of b to bp \n";
17   cout << "Calling bp->f1() ";
18   bp->f1();
19   cout << "Calling bp->v1() ";
20   bp->v1();
21   cout << "Calling bp->fskip() ";
22   bp->fskip();
23
24   // these calls also illustrate straight forward calls using a known object of type derived 1
25   // and a pointer of type pointer to derived1 holding the address of a derived 1 class object
26   derived1 d1;
27   derived1 * dp1 = & d1;
28
29   cout << "\n\nCalling d1.f1() ";
30   d1.f1();          // derived f1 called, d1 determines
31   cout << "Calling d1.v1() ";
32   d1.v1();          // derived v1 called, d1 determines
33   cout << "Calling d1.fskip() ";
34   d1.fskip();       // base called, no fskip in derived1 class
35                     // therefore d1 determines through inheritance
36                     // relationship with base
37   cout << "Calling d1.f2() ";
38   d1.f2();          // derived f2 called, d1 determines
39   cout << "Calling d1.v2() ";
40   d1.v2();          // derived v2 called, d1 determines
41
42   cout << "\nHave assigned &d1 to dp1 \n";
43   cout << "Calling dp1->f1() ";
44   dp1->f1();        // derived f1 called, dp1 determines
45   cout << "Calling dp1->v1() ";
46   dp1->v1();        // derived v1 called, dp1 determines
47   cout << "Calling dp1->fskip() ";
48   dp1->fskip();     // base called, no fskip in derived1 class
49                     // therefore dp1 determines through inheritance
50                     // relationship with base
51   cout << "Calling dp1->f2() ";
52   dp1->f2();        // derived f2 called, dp1 determines
53   cout << "Calling dp1->v2() ";
54   dp1->v2();        // derived v2 called, dp1 determines

```



```

1 // these calls also illustrate straight forward calls using a known object of type derived 2
2 // and a pointer of type pointer to derived2 holding the address of a derived 2 class object
3 derived2 d2;
4 derived2 * dp2 = & d2;
5 cout << "\n\nCalling d2.f1() ";
6 d2.f1(); // derived f1 called, d2 determines
7 cout << "Calling d2.v1() ";
8 d2.v1(); // derived v1 called, d2 determines
9 cout << "Calling d2.fskip() ";
10 d2.fskip(); // derived called, d2 determines
11 cout << "Calling d2.f2()";
12 d2.f2(); // derived f2 called, d2 determines
13 cout << "Calling d2.v2() ";
14 d2.v2(); // derived v2 called, d2 determines
15
16 cout << "\nHave assigned &d2 to dp2\n";
17 cout << "Calling dp2->f1() ";
18 dp2->f1(); // derived f1 called, dp2 determines
19 cout << "Calling dp2->v1() ";
20 dp2->v1(); // derived f1 called, dp2 determines
21 cout << "Calling dp2->fskip() ";
22 dp2->fskip(); // derived called
23 cout << "Calling dp2->f2() ";
24 dp2->f2(); // derived f2 called, dp2 determines
25 cout << "Calling dp2->v2() ";
26 dp2->v2(); // derived v2 called, dp2 determines
27
28 // now assign the address of a derived1 object to bp
29 cout << "\n\nHave assigned &d1 to bp " << endl;
30 bp = & d1;
31 cout << "Calling bp->f1() ";
32 bp->f1(); // base called, bp determines
33 cout << "Calling bp->v1() ";
34 bp->v1(); // derived called, &d1 determines
35 cout << "Calling bp->fskip() ";
36 bp->fskip(); // base called, no fskip in derived1 class
37 //cout << "Calling bp->f2() ";
38 // bp->f2(); CANNOT MAKE THIS CALL
39 //cout << "Calling bp->v2() ";
40 // bp->v2(); CANNOT MAKE THIS CALL
41 cout << endl << endl;
42 // now assign the address of a derived2 object to bp
43 cout << "\n\nHAVE ASSIGNED &d2 to bp " << endl;
44 bp = & d2;
45 cout << "Calling bp->f1() ";
46 bp->f1(); // base called, bp determines
47 cout << "Calling bp->v1() ";
48 bp->v1(); // derived called, &d1 determines
49 cout << "Calling bp->fskip() ";
50 bp->fskip(); // base called, bp determines
51 //cout << "Calling bp->f2() ";
52 //bp->f2(); CANNOT MAKE THIS CALL
53 //cout << "Calling bp->v2() ";
54 //bp->v2(); CANNOT MAKE THIS CALL

```

```

1 // now assign the address of a derived2 object to dp1
2 dp1 = & d2;
3 cout << "\n\nHave Assigned &d2 to dp1 " << endl;
4 cout << "Calling dp1->f1() ";
5 dp1->f1(); // derived1::f1 is called
6 cout << "Calling dp1->v1() ";
7 dp1->v1(); // derived2::v1 is called
8 cout << "Calling dp1->fskip() ";
9 dp1->fskip(); // base::fskip is called
10 cout << "Calling dp1->f2() ";
11 dp1->f2(); // derived1::f2 is called
12 cout << "Calling dp1->v2() ";
13 dp1->v2(); // derived2::v2 is called
14}

```

```

1Output From Running Program
2
3Calling b.fl() In base::fl
4Calling b.v1() In base::v1
5Calling b.fskip() In base::fskip
6
7Have assigned address of b to bp
8Calling bp->fl() In base::fl
9Calling bp->v1() In base::v1
10Calling bp->fskip() In base::fskip
11
12Calling d1.fl() In derived1::fl
13Calling d1.v1() In derived1::v1
14Calling d1.fskip() In base::fskip
15Calling d1.f2() In derived1::f2
16Calling d1.v2() In derived1::v2
17
18Have assigned &d1 to dp1
19Calling dp1->fl() In derived1::fl
20Calling dp1->v1() In derived1::v1
21Calling dp1->fskip() In base::fskip
22Calling dp1->f2() In derived1::f2
23Calling dp1->v2() In derived1::v2
24
25Calling d2.fl() In derived2::fl
26Calling d2.v1() In derived2::v1
27Calling d2.fskip() In derived2::fskip
28Calling d2.f2() In derived2::f2
29Calling d2.v2() In derived2::v2
30
31Have assigned &d2 to dp2
32Calling dp2->fl() In derived2::fl
33Calling dp2->v1() In derived2::v1
34Calling dp2->fskip() In derived2::fskip
35Calling dp2->f2() In derived2::f2
36Calling dp2->v2() In derived2::v2
37
38Have assigned &d1 to bp
39Calling bp->fl() In base::fl
40Calling bp->v1() In derived1::v1
41Calling bp->fskip() In base::fskip
42
43HAVE ASSIGNED &d2 to bp
44Calling bp->fl() In base::fl
45Calling bp->v1() In derived2::v1
46Calling bp->fskip() In base::fskip
47
48Have Assigned &d2 to dp1
49Calling dp1->fl() In derived1::fl
50Calling dp1->v1() In derived2::v1
51Calling dp1->fskip() In base::fskip
52Calling dp1->f2() In derived1::f2
53Calling dp1->v2() In derived2::v2

```

```

1// name.h
2// introduce the name class
3// This is a class that I came up with to model a human name
4// It is far from complete but it gives you the idea
5// This class and an associated class, address, are going to be
6// EMBEDDED in another class
7
8// our class descriptions will be in files labelled      .h
9// the implementations of a class will be in files labelled .cpp
10// programs to test a class will be in files labelled   _____.cpp
11
12// this mechanism prevents this .h file from being included more than once
13// this is important to do if you are going to embed classes or inherit
14#ifndef NAME_PROTECTOR
15#define NAME_PROTECTOR
16
17#include <iostream.h>
18#include <string.h>
19
20#define      MAX_NAME_LEN      50
21
22class name
23{
24    private:
25        char n[MAX_NAME_LEN];    // the characters to store
26        int len;                 // length of stored name
27        int initialized;         // has the name been set yet?
28    public:
29        void print_name();        // function to print a name
30        void set_name(char *);    // function to change a name
31        void get_name_from_user();
32
33        name(char *);             // one argument constructor
34        name();                   // no argument constructor
35
36        int is_it_initialized();  // returns 0 if name has not been set
37        int what_is_len();        // return value of len field
38        char * what_is_name();    // return the value of n field
39};
40#endif

```

```

1// name.cpp
2// implement the name class described in name.h
3#include <iostream.h>
4#include <stdlib.h>
5#include "name.h"
6
7void name::print_name()
8{
9    cout << n << endl;    // print out the name field
10}
11
12// receive a name, error check on length, prompt if necessary
13void name::set_name(char * s)
14{
15    len = strlen(s);    // get length of new name
16    while ( len > MAX_NAME_LEN )
17    {
18        cout << "Name is too long, try again" << endl;
19        cin >> s;
20        len = strlen(s);
21    }
22    strcpy(&n[0],s);    // copy new name into new area of memory
23    initialized = 1;    // set the initialized field
24    return;
25}

```

```

1 void name::get_name_from_user()
2 {
3     char temp [MAX_NAME_LEN * 2];
4     char * tptr = &temp[0];
5     char inchar;
6
7     cout << "What is your name?\n";
8
9     // account for any carriage return that may have been left over
10    cin.get(inchar);
11    if ( inchar == '\n' )
12    {
13        // go ahead and get next char, looking for non cr
14        cin.get(inchar);
15    }
16
17    // continue to read characters until next new line is encountered
18    while ( inchar != '\n' )
19    {
20        *tptr++ = inchar;
21        cin.get(inchar);
22    }
23    *tptr = NULL;           // replace the newline with a null
24    len = strlen(temp);     // get length of new name
25    while ( len > MAX_NAME_LEN )
26    {
27        cout << "Name is too long, try again" << endl;
28        cout << "What is your name?\n";
29
30        tptr = &temp[0];
31        cin.get(inchar);
32
33        while ( inchar != '\n' )
34        {
35            *tptr++ = inchar;
36            cin.get(inchar);
37        }
38
39        *tptr = '\0';
40        len = strlen(temp);
41    }
42    strcpy(&n[0],temp);     // copy new name into new area of memory
43    initialized = 1;       // set the initialized field
44    return;
45 }

```

```

1name::name(char * s)
2{
3#ifdef TRACE
4    cout << "name char * constructor called \n";
5#endif
6    len = strlen(s);           // get length of new name
7    while ( len > MAX_NAME_LEN )
8    {
9        cout << "Name is too long, try again" << endl;
10       cin >> s;
11       len = strlen(s);
12    }
13
14    strcpy(&n[0],s);           // copy new name into new area of memory
15    initialized = 1;           // set the initialized field
16    return;
17}
18
19// this is the no argument constructor
20name::name()
21{
22#ifdef TRACE
23    cout << "name no arg constructor called \n";
24#endif
25
26    len = strlen("Uninitialized Name");           // get length of new name
27    strcpy(&n[0],"Uninitialized Name");           // copy name into memory
28    initialized = 0;                               // set the initialized field to not set
29    return;
30}
31
32// these are convenience functions which provide access to private data
33int name::what_is_len()
34{
35    return(len);
36}
37
38char * name::what_is_name()
39{
40    return(n);
41}
42
43int name::is_it_initialized()
44{
45    return(initialized);
46}

```

```

1// drv_name.cpp
2// to compile this program use
3// tcc drv_name.cpp name.cpp
4
5// this program will exercise the name class
6// it tries to call every function that is implemented in the name class
7// A program like this is invaluable in the documentation of your class
8
9#include <iostream.h>
10#include "name.h"
11
12main()
13{
14    // Cause the no argument constructor to be invoked
15    name n1;
16    cout << "Calling print_name for uninitialized n1 \n";
17    n1.print_name();
18    cout << "return value from what_is_len is " << n1.what_is_len() << endl;
19    cout << "return value from initialized is " << n1.is_it_initialized() << endl;
20
21    // exercise the set_name function
22    n1.set_name("John Timothy Kalnay");
23    cout << "Repeating call sequence after setting name to jtk\n";
24    n1.print_name();
25    cout << "return value from what_is_len is " << n1.what_is_len() << endl;
26    cout << "return value from initialized is " << n1.is_it_initialized() << endl;
27
28    // cause the one arg constructor to be called
29    name n2("Dr. Susann Marie Brady Kalnay");
30    cout << "Repeating call sequence after creating n2 with name in it\n";
31    n2.print_name();
32    cout << "return value from what_is_len is " << n2.what_is_len() << endl;
33    cout << "return value from initialized is " << n2.is_it_initialized() << endl;
34
35    name n3;
36    n3.get_name_from_user();
37    n3.print_name();
38    cout << "return value from what_is_len is " << n3.what_is_len() << endl;
39    cout << "return value from initialized is " << n3.is_it_initialized() << endl;
40}

```


1Output From Running Program
2
3Calling print_name for uninitialized n1
4Uninitialized Name
5return value from what_is_len is 18
6return value from initialized is 0
7Repeating call sequence after setting name to jtk
8John Timothy Kalnay
9return value from what_is_len is 19
10return value from initialized is 1
11Repeating call sequence after creating n2 with name in it
12Dr. Susann Marie Brady Kalnay
13return value from what_is_len is 29
14return value from initialized is 1

1// address.h

```
2// introduce the address class
3// ask yourself if this differs from the name class? Could name and address both be instances of a
4// string -like class?
5#ifndef ADDRESS_PROTECTOR
6#define ADDRESS_PROTECTOR
7
8#include <iostream.h>
9#include <string.h>
10
11#define MAX_ADDRESS_LEN 50
12
13class address
14{
15    private:
16        char a[MAX_ADDRESS_LEN];
17        int len; // length of stored address
18        int initialized; // has an addr been stored in there?
19    public:
20        void print_address(); // function to print an address
21        void set_address(char *); // function to change an address
22        void get_address_from_user(); // do what name says
23
24        address(char *); // one argument constructor
25        address(); // no argument constructor
26
27        int is_it_initialized(); // returns 0 if address has been set
28        int what_is_len(); // return value of len field
29
30        char * what_is_address(); // return the a field
31};
32#endif
```

```

1// address.cpp
2// implement the address class
3#include <iostream.h>
4#include <stdio.h>
5#include <stdlib.h>
6#include "address.h"
7
8void address::print_address()
9{
10    cout << a << endl;
11}
12
13void address::set_address(char * s)
14{
15    len = strlen(s);          // get length of new address
16    if ( len > MAX_ADDRESS_LEN )
17    {
18        cout << "address is too long \n";
19        exit(-1);            // this is drastic, could do an error checking loop instead
20    }
21    strcpy(a,s);              // copy new address into new area of memory
22    initialized = 1;          // set the initialized field
23    return;
24}
25
26address::address(char * s) {
27#ifdef TRACE
28    cout << "address char * constructor called \n";
29#endif
30    len = strlen(s);          // get length of new address
31    if ( len > MAX_ADDRESS_LEN ) {
32        cout << "address is too long \n";
33        exit(-1);            // this is drastic, could error check instead
34    }
35    strcpy(a,s);              // copy new address into new area of memory
36    initialized = 1;          // set the initialized field
37    return;
38}
39
40address::address()           {
41#ifdef TRACE
42    cout << "address no arg constructor called \n";
43#endif
44    len = strlen("Uninitialized address");    // get length of new address
45    if ( len > MAX_ADDRESS_LEN )
46    {
47        cout << "address is too long \n";
48        exit(-1);
49    }
50    strcpy(a,"Uninitialized address");        // copy into new area of memory
51    initialized = 0;                          // set the initialized field to not set
52    return;
53}

```

```

1 void address::get_address_from_user()
2 {
3     char temp[MAX_ADDRESS_LEN * 2];
4     char * aptr = & temp[0];
5     char inchar;
6
7     cout << "What is your address? \n";
8     cin.get(inchar);
9     if ( inchar == '\n' )
10    {        // then we found a leading \n, dump it
11        cin.get(inchar);
12    }
13    while ( inchar != '\n' )
14    {
15        *aptr++ = inchar;
16        cin.get(inchar);
17    }
18    *aptr = NULL;
19
20    len = strlen(temp);        // get length of new address
21    while ( len > MAX_ADDRESS_LEN )
22    {
23        cout << "address is too long\n";
24        cout << "What is your shorter address? \n";
25
26        aptr = &temp[0];
27        cin.get(inchar);
28
29        while ( inchar != '\n' )
30        {
31            *aptr++ = inchar;
32            cin.get(inchar);
33        }
34        *aptr = NULL;
35
36        len = strlen(temp);
37    }
38    strcpy(a,temp);        // copy into new area of memory
39    initialized = 1;        // set the initialized field to not set
40    return;
41 }
42
43 int address::what_is_len()
44 {
45     return(len);
46 }
47 char * address::what_is_address()
48 {
49     return(a);
50 }
51 int address::is_it_initialized()
52 {
53     return(initialized);
54 }

```

1// drv_addr.cpp

2// program to exercise the address class

3#include <iostream.h>

4#include "address.h"

5

6main()

7{

8 address a1;

9 cout << "Calling print_address for uninitialized n1 \n";

10 a1.print_address();

11 cout << "return value from what_is_len is " << a1.what_is_len() << endl;

12 cout << "return value from initialized is " << a1.is_it_initialized() << endl;

13 cout << "The address returned from what_is_address is " <<

14 a1.what_is_address() << endl;

15

16 a1.set_address("600 Pine Hollow Road");

17 cout << "Repeating call sequence after setting address to home\n";

18 a1.print_address();

19 cout << "return value from what_is_len is " << a1.what_is_len() << endl;

20 cout << "return value from initialized is " << a1.is_it_initialized() << endl;

21 cout << "The address returned from what_is_address is " <<

22 a1.what_is_address() << endl;

23

24

25 address a2("108 Bridge Street East");

26 cout << "Repeating call sequence after creating a2 with addr in it\n";

27 a2.print_address();

28 cout << "return value from what_is_len is " << a2.what_is_len() << endl;

29 cout << "return value from initialized is " << a2.is_it_initialized() << endl;

30 cout << "The address returned from what_is_address is " <<

31 a2.what_is_address() << endl;

32

33 address a3;

34 a3.get_address_from_user();

35 cout << "return value from what_is_len is " << a3.what_is_len() << endl;

36 cout << "return value from initialized is " << a3.is_it_initialized() << endl;

37 cout << "The address returned from what_is_address is " <<

38 a3.what_is_address() << endl;

39}

1 Output From Running Program
2
3 Calling print_address for uninitialized n1
4 Uninitialized address
5 return value from what_is_len is 21
6 return value from initialized is 0
7 Repeating call sequence after setting address to home
8 8600 Pine Hollow Road
9
10 return value from what_is_len is 20
11 return value from initialized is 1
12
13 Repeating call sequence after creating a2 with addr in it
14 108 Bridge Street East
15 return value from what_is_len is 22
16 return value from initialized is 1

1// polyarry.cpp

```
2// this program demonstrates the usefulness of virtual functions and of base classes
3// we are going to have objects of type army, navy, airforce and marines which all derive from a base
4// class called common_class. The common_class collects all the behaviour that is common between
5// the classes and through the use of virtual functions makes the writing of the derived classes much
6// easier.
7#include <iostream.h>
8#include "name.h"
9#include "address.h"
10class common_class
11{
12    private:
13        name    n;           // this is embedded, it is not derived
14        address a;           // this also is embedded, it is not derived
15    public:
16        common_class(); // no arg constructor
17        void q1();       // question common to services
18        void q2();       // question common to services
19        virtual void q3(); // question specific to service
20        virtual void print_vals(); // will allow each class derived from this class to use their
21                                // own function of the same name and call this function too
22};
23
24// no argument constructor
25common_class::common_class() : n("no name yet"), a("no address yet")
26{    // invocation line initialization was employed, therefore there is no body to this constructor
27}
28
29void common_class::print_vals()
30{
31    n.print_name();       // access the public member function of the embedded class
32    a.print_address();     // access the public member function of the embedded class
33}
34void common_class::q1()
35{
36    // this question is used to get the recruits name
37    n.get_name_from_user(); // public member function of embedded class
38}
39
40void common_class::q2()
41{
42    // this question is used to get the recruits address
43    a.get_address_from_user(); // public member function of embedded class
44}
45
46void common_class::q3()
47{
48    // this function only does something if the derived class
49    // does not re-implement the function
50    cout << "I know you haven't decided which service you want \n"
51         << "to go into, so let me give you some information \n"
52         << "on each!" << endl;
53}
```

```

1// An army class IS a common_class and the additional fields and functions listed here
2// because q3 and print_vals were declared virtual in the base class, and because they are redefined
3// here, the binding of which function will be called can be delayed until run time if pointers are used
4// instead of instance names. The value of this is in being able to call the function q3 for each of the
5// deriving classes without having to have the instance name of the deriving class. The array below
6// demonstrates this.
7class army : public common_class
8{
9    private:
10        int max_miles_run;        // 0 to 100
11    public:
12        void q3();
13        void print_vals();
14};
15
16void army::print_vals()
17{
18    cout << "ARMY RECRUIT \n";
19    common_class::print_vals();    // use the base class routine
20    cout << "Can run " << max_miles_run << " At a time \n\n";
21}
22
23void army::q3()
24{
25    // get the number of miles the recruit can run
26    cout << "How many miles can you run?";
27    cin >> max_miles_run;        // ERROR CHECKING COULD BE DONE HERE
28}
29
30// a navy class is a common_class and the additional fields and functions defined here
31class navy : public common_class {
32    private:
33        char can_you_swim;        // n no, y yes
34    public:
35        void q3();
36        void print_vals();
37};
38
39void navy::q3() {
40    // question used to ask if the recruit can swim or not
41    cout << "Can you swim?  n => no   y => yes \n";
42    cin >> can_you_swim;
43    if ( can_you_swim == 'n' )
44        cin >> can_you_swim;
45}
46void navy::print_vals() {
47    cout << "NAVY RECRUIT \n";
48    common_class::print_vals();
49    if ( can_you_swim == 'n' )
50        cout << "Cannot Swim \n";
51    else
52        cout << "Can Swim \n";
53    cout << endl;
54}

```



```

1// an air force class is a common_class and the extra fields and functions defined here
2class air_force : public common_class
3{
4    private:
5        char afraid_of_heights;    // n no, y yes
6    public:
7        void q3();
8        void print_vals();
9};
10
11void air_force::q3()
12{
13    // question used to ask if the recruit is afraid of heights
14    cout << "Are you afraid of heights?  n => no  y => yes \n";
15    cin >> afraid_of_heights;
16    if ( afraid_of_heights == '\n' )
17        cin >> afraid_of_heights;
18}
19
20void air_force::print_vals()
21{
22    cout << "AIR FORCE RECRUIT \n";
23    common_class::print_vals();
24    if ( afraid_of_heights == 'n' )
25        cout << "Is not afraid of heights\n";
26    else
27        cout << "Is afraid of heights \n";
28    cout << endl;
29}
30
31class marines : public common_class
32{
33    private:
34    public:
35        void q3();
36        void print_vals();
37};
38
39void marines::print_vals()
40{
41    cout << "MARINE RECRUIT \n";
42    common_class::print_vals();
43    cout << endl;
44}
45
46void marines::q3()
47{
48    return;    // no additional work done
49}

```

```

1main()
2{
3    // At the armed forces in-processing center all of the freshly shaved recruits came to the head
4    // of the line, The common information that all the services needed from us, name,
5    // address, social security number etc. were gathered by one sergeant. This sergeant
6    // didn't know and didn't care what service each recruit was going into. The sergeants
7    // job was the same regardless of what service we were going in. Next, the special
8    // information for each individual service was gathered at special counters,
9    // i.e. one counter for the navy, one for the air force, one for the army
10   // After our special information was acquired, we were all the same again for the next test
11   // so the system had to have a way to treat us all as RECRUITS again, not as army, or navy
12   // recruits. This is very powerful in data processing, being able to process a data structure
13   // at one time from one point of view, taking into account how it is SIMILAR to all other things
14   // and then at the next moment being able to process that same data structure from another
15   // point of view that takes into account how it is DIFFERENT from other things.
16   // Pointers to base class objects holding addresses of base class objects and addresses
17   // of derived class objects are extremely useful in modelling this situation.
18
19   common_class * array[100];    // assume there's less than 100 people
20                                 // waiting to join the armed forces today
21
22   // we are going to build an array that
23   // represents a line of recruits waiting at the induction center
24   // for the armed forces
25   // the sergeant is going to ask ALL RECRUITS some questions
26   // and then each recruit, based on their service, is going
27   // to be asked specific questions
28
29   int i;
30   int num_recruits;
31
32   cout << "How many people are waiting? ";
33   cin >> num_recruits;
34
35   cout << "Each recruit is asked what service \n"
36         << "They would like to join \n"
37         << "\t0\tArmy\n"
38         << "\t1\tNavy\n"
39         << "\t2\tAir Force\n"
40         << "\t3\tMarines\n"
41         << "\t4\tDoesn't Know\n\n";

```

```

1   for ( i = 0; i < num_recruits; i++ )
2   {
3       int service;
4
5       cout << "\n\nWhich service does recruit " << i
6           << " wish to join?" << endl;
7       cin >> service;
8
9       // the statement array[i] = new army/navy/air_force/marines is an extremely powerful
10      // statement. Even though we are creating instances of four different classes, we are
11      // storing the pointer to the instances in ONE DATA STRUCTURE which is of
12      // type pointer to base class that they are derived from. Instead of needing four
13      // data structures, one for each service, we are able to have one data structure. This
14      // can be extremely useful in reducing the complexity of algorithms.
15      switch (service )
16      {
17          case 0:
18              cout << "Recruit " << i
19                  << " is going in the army\n";
20              array[i] = new army;
21              break;
22          case 1:
23              cout << "Recruit " << i
24                  << " is going in the navy\n";
25              array[i] = new navy;
26              break;
27
28          case 2:
29              cout << "Recruit " << i
30                  << " is going in the air force\n";
31              array[i] = new air_force;
32              break;
33
34          case 3:
35              cout << "Recruit " << i
36                  << " is going in the marines\n";
37              array[i] = new marines;
38              break;
39
40          default:
41              // later on, when they decide what service
42              // they are going in, we will have to be
43              // able to cast from base to derived
44              cout << "Recruit " << i
45                  << " doesn't know where they're"
46                  << " going \n";
47              array[i] = new common_class;
48              break;
49      } // end switch
50

```

```

1      // We are now going to exercise another useful feature of inheritance and virtual
2      // functions. The questions q1 and q2 are defined in the base class only. The binding
3      // of these calls is unambiguous. We are able to call the q1 of the base class for
4      // members of each of the four deriving classes via a pointer to the base class
5      // NOTICE that we do not have to switch on which service the recruit is in to be
6      // able to call these functions.
7      array[i]->q1();
8      array[i]->q2();
9
10     // ask the specific questions
11     // the question q3 is specific to each of the services, and yet we can call it via a pointer
12     // to the base class. We are able to call four DIFFERENT functions, but with one line
13     // of syntactically exact code. Remember that q3 is a virtual function. We are invoking
14     // it via a pointer to a base class. If the value in the array is an instance of the base class
15     // then the base class function will be called. If the value in the array is an instance of
16     // a derived class, and the derived class has a polymorphic version of the virtual function,
17     // then the derived class function will be called.
18     // NOTICE that we do not have to switch on which service the recruit is in to be able
19     // to ask this service specific question. Due to how the virtual function call will be
20     // resolved, if the service has overridden this call, the service specific call will be made
21     // if the service has not overridden this call, the common class call will be made
22     // if the recruit is an undecided class recruit, then the base class version will be called.
23     array[i]->q3();
24 }
25
26 // go through the array and print out the common fields
27 // name and address
28 // and the specific values found in the objects
29 cout << "\n\nLIST OF RECRUITS\n";
30 for ( i = 0; i < num_recruits; i++ )
31 {
32     array[i]->print_vals();
33 }
34}

```

1Input Data File Used To Generate Output

212
30
4army guy 1
5100 army way
610
71
8navy guy 1
9123 navy street
10y
111
12navy guy 2
13222 navy blvd
14n
152
16air force recruit 1
1799 air force court
18n
192
20air force recruit 2
21100 air force way
22y
233
24marine guy 1
25123 marine street
263
27marine guy 2
28222 marine blvd
294
30undecided recruit 1
3199 wishy washy way
322
33air force recruit 3
34100 air force way
35y
363
37marine guy 3
38999 marine street
393
40marine guy 4
412354222 marine blvd
424
43undecided recruit 2
44100 don't know where I live

```

1Output From Running Program
2How many people are waiting? Each recruit is asked what service
3They would like to join
4      0      Army
5      1      Navy
6      2      Air Force
7      3      Marines
8      4      Doesn't Know
9
10
11
12Which service does recruit 0 wish to join?
13Recruit 0 is going in the army
14What is your name?
15What is your address?
16How many miles can you run?
17
18Which service does recruit 1 wish to join?
19Recruit 1 is going in the navy
20What is your name?
21What is your address?
22Can you swim?  n => no  y => yes
23
24
25Which service does recruit 2 wish to join?
26Recruit 2 is going in the navy
27What is your name?
28What is your address?
29Can you swim?  n => no  y => yes
30
31
32Which service does recruit 3 wish to join?
33Recruit 3 is going in the air force
34What is your name?
35What is your address?
36Are you afraid of heights?  n => no  y => yes
37
38
39Which service does recruit 4 wish to join?
40Recruit 4 is going in the air force
41What is your name?
42What is your address?
43Are you afraid of heights?  n => no  y => yes
44
45
46Which service does recruit 5 wish to join?
47Recruit 5 is going in the marines
48What is your name?
49What is your address?
50
51
52Which service does recruit 6 wish to join?
53Recruit 6 is going in the marines
54What is your name?
55What is your address?
56

```

1
 2Which service does recruit 7 wish to join?
 3Recruit 7 doesn't know where they're going
 4What is your name?
 5What is your address?
 6I know you haven't decided which service you want
 7to go into, so let me give you some information
 8on each!
 9
 10
 11Which service does recruit 8 wish to join?
 12Recruit 8 is going in the air force
 13What is your name?
 14What is your address?
 15Are you afraid of heights? n => no y => yes
 16
 17
 18Which service does recruit 9 wish to join?
 19Recruit 9 is going in the marines
 20What is your name?
 21What is your address?
 22
 23
 24Which service does recruit 10 wish to join?
 25Recruit 10 is going in the marines
 26What is your name?
 27What is your address?
 28
 29
 30Which service does recruit 11 wish to join?
 31Recruit 11 doesn't know where they're going
 32What is your name?
 33What is your address?
 34I know you haven't decided which service you want
 35to go into, so let me give you some information
 36on each!
 37
 38
 39LIST OF RECRUITS
 40ARMY RECRUIT
 41army guy 1
 42100 army way
 43Can run 10 At a time
 44
 45NAVY RECRUIT
 46navy guy 1
 47123 navy street
 48Can Swim
 49
 50NAVY RECRUIT
 51navy guy 2
 52222 navy blvd
 53Cannot Swim
 54
 55AIR FORCE RECRUIT
 56air force recruit 1

199 air force court
2Is not afraid of heights
3
4AIR FORCE RECRUIT
5air force recruit 2
6100 air force way
7Is afraid of heights
8
9MARINE RECRUIT
10marine guy 1
11123 marine street
12
13MARINE RECRUIT
14marine guy 2
15222 marine blvd
16
17undecided recruit 1
1899 wishy washy way
19AIR FORCE RECRUIT
20air force recruit 3
21100 air force way
22Is afraid of heights
23
24MARINE RECRUIT
25marine guy 3
26999 marine street
27
28MARINE RECRUIT
29marine guy 4
302354222 marine blvd
31
32undecided recruit 2
33100 don't know where I live
34

1Section 8

2

3Dynamic Memory Allocation

4

5C++ replaces malloc, calloc and free with new and delete.

6C++ also provides constructors that allow code we have written to be called when an instance of an object
7is created. This provides us with a great opportunity to guarantee the initial states of our objects. This
8chapter goes over every last little detail there is involved with dynamic memory allocation.

9

10new1.cpp this program introduces the very basics of new as applied to pre defined types

11

12new2.cpp using new with a user defined structure

13

14new3.cpp using new to create arrays of pre defined types

15

16new4.cpp using new to create arrays of user defined structures

17

18new5.cpp using new with user defined classes

19

20new6.cpp new and arrays of user defined classes

21

22new7.cpp new with a class embedded inside another class

23

how is the memory allocation for the embedded class handled

24

25new8.cpp new and inheritance

26

27new9.cpp new and arrays of inherited objects

28

29new10.cpp overloading the new operator for a user defined class

30

```

1// new1.cpp
2// new replaces malloc and calloc from C
3// malloc can still be used, calloc can still be used
4// delete replaces free from C
5
6#include <iostream.h>
7#include <stdlib.h>
8main()
9{
10    int * iarray = new int [10];
11    float * farray = new float [10];
12    char * carray = new char [10];
13
14    cout << "Size of iarray is " << sizeof(iarray) << endl;
15    cout << "Size of farray is " << sizeof(farray) << endl;
16    cout << "Size of carray is " << sizeof(carray) << endl;
17
18    cout << "Size of *iarray is " << sizeof(*iarray) << endl;
19    cout << "Size of *farray is " << sizeof(*farray) << endl;
20    cout << "Size of *carray is " << sizeof(*carray) << endl;
21
22    int i;
23    for ( i = 0; i < 10; i++ )
24    {
25        iarray[i] = (int) i;
26        farray[i] = (float) i;
27        carray[i] = 'a' + i;
28    }
29
30    char temp;
31    for ( i = 0; i < 10; i++ )
32    {
33        cout << "Address of iarray sub " << i << " is "
34            << &iarray[i] << " Value stored there is "
35            << iarray[i] << endl;
36        cout << "Value stored at farray sub " << i << " is "
37            << farray[i] << endl;
38        temp = carray[i];
39        cout << "Value stored at carray sub " << i << " is "
40            << temp << endl;
41    }
42}

```

1Output From Running Program
2Size of iarray is 2
3Size of farray is 2
4Size of carray is 2
5Size of *iarray is 2
6Size of *farray is 4
7Size of *carray is 1
8Address of iarray sub 0 is 0x1f9f1460 Value stored there is 0
9Value stored at farray sub 0 is 0
10Value stored at carray sub 0 is a
11Address of iarray sub 1 is 0x1f9f1462 Value stored there is 1
12Value stored at farray sub 1 is 1
13Value stored at carray sub 1 is b
14Address of iarray sub 2 is 0x1f9f1464 Value stored there is 2
15Value stored at farray sub 2 is 2
16Value stored at carray sub 2 is c
17Address of iarray sub 3 is 0x1f9f1466 Value stored there is 3
18Value stored at farray sub 3 is 3
19Value stored at carray sub 3 is d
20Address of iarray sub 4 is 0x1f9f1468 Value stored there is 4
21Value stored at farray sub 4 is 4
22Value stored at carray sub 4 is e
23Address of iarray sub 5 is 0x1f9f146a Value stored there is 5
24Value stored at farray sub 5 is 5
25Value stored at carray sub 5 is f
26Address of iarray sub 6 is 0x1f9f146c Value stored there is 6
27Value stored at farray sub 6 is 6
28Value stored at carray sub 6 is g
29Address of iarray sub 7 is 0x1f9f146e Value stored there is 7
30Value stored at farray sub 7 is 7
31Value stored at carray sub 7 is h
32Address of iarray sub 8 is 0x1f9f1470 Value stored there is 8
33Value stored at farray sub 8 is 8
34Value stored at carray sub 8 is i
35Address of iarray sub 9 is 0x1f9f1472 Value stored there is 9
36Value stored at farray sub 9 is 9
37Value stored at carray sub 9 is j
38

```

1//new2.cpp
2// new also works with structures
3// new will return a pointer to an instance of the desired structure
4// type that you request.
5// If new returns NULL as the address of the new variable,
6//      then the dynamic memory allocation failed
7#include <iostream.h>
8
9struct XY
10{
11    int x;
12    float y;
13};
14
15main()
16{
17    struct XY * X = new struct XY;
18
19    cout << "new returned " << X << endl;
20    cout << "Size of X is " << sizeof(X) << endl;
21    cout << "Size of *X is " << sizeof(*X) << endl;
22}
23
24
25Output From Running Program
26new returned 0x18140fe6
27Size of X is 2
28Size of *X is 6

```

1// new3.cpp

2// new is not limited to creating single instances of variables

3// new can be used to create arrays

4#include <iostream.h>

5main()

6{

7 int * iarray = new int [10];

8 float * farray = new float [10];

9 char * carray = new char [10];

10

11 cout << "Size of iarray is " << sizeof(iarray) << endl;

12 cout << "Size of farray is " << sizeof(farray) << endl;

13 cout << "Size of carray is " << sizeof(carray) << endl;

14

15 cout << "Size of *iarray is " << sizeof(*iarray) << endl;

16 cout << "Size of *farray is " << sizeof(*farray) << endl;

17 cout << "Size of *carray is " << sizeof(*carray) << endl;

18

19 int i;

20 for (i = 0; i < 10; i++)

21 {

22 iarray[i] = (int) i;

23 farray[i] = (float) i;

24 carray[i] = 'a' + i;

25 }

26

27 char temp;

28 for (i = 0; i < 10; i++)

29 {

30 cout << "Address of iarray sub " << i << " is"

31 << &iarray[i] << " Value stored there is "

32 << iarray[i] << endl;

33 cout << "Address of farray sub " << i << " is"

34 << &farray[i] << " Value stored there is "

35 << farray[i] << endl;

36

37 temp = carray[i];

38 cout << "Value stored at carray sub " << i << " is "

39 << temp << endl;

40 }

41}

1Output From Running Program
 2Size of iarray is 2
 3Size of farray is 2
 4Size of carray is 2
 5
 6Size of *iarray is 2
 7Size of *farray is 4
 8Size of *carray is 1
 9
 10Address of iarray sub 0 is0x1c5f1470 Value stored there is 0
 11Address of farray sub 0 is0x1c5f1488 Value stored there is 0
 12Value stored at carray sub 0 is a
 13
 14Address of iarray sub 1 is0x1c5f1472 Value stored there is 1
 15Address of farray sub 1 is0x1c5f148c Value stored there is 1
 16Value stored at carray sub 1 is b
 17
 18Address of iarray sub 2 is0x1c5f1474 Value stored there is 2
 19Address of farray sub 2 is0x1c5f1490 Value stored there is 2
 20Value stored at carray sub 2 is c
 21
 22Address of iarray sub 3 is0x1c5f1476 Value stored there is 3
 23Address of farray sub 3 is0x1c5f1494 Value stored there is 3
 24Value stored at carray sub 3 is d
 25
 26Address of iarray sub 4 is0x1c5f1478 Value stored there is 4
 27Address of farray sub 4 is0x1c5f1498 Value stored there is 4
 28Value stored at carray sub 4 is e
 29
 30Address of iarray sub 5 is0x1c5f147a Value stored there is 5
 31Address of farray sub 5 is0x1c5f149c Value stored there is 5
 32Value stored at carray sub 5 is f
 33
 34Address of iarray sub 6 is0x1c5f147c Value stored there is 6
 35Address of farray sub 6 is0x1c5f14a0 Value stored there is 6
 36Value stored at carray sub 6 is g
 37
 38Address of iarray sub 7 is0x1c5f147e Value stored there is 7
 39Address of farray sub 7 is0x1c5f14a4 Value stored there is 7
 40Value stored at carray sub 7 is h
 41
 42Address of iarray sub 8 is0x1c5f1480 Value stored there is 8
 43Address of farray sub 8 is0x1c5f14a8 Value stored there is 8
 44Value stored at carray sub 8 is i
 45
 46Address of iarray sub 9 is0x1c5f1482 Value stored there is 9
 47Address of farray sub 9 is0x1c5f14ac Value stored there is 9
 48Value stored at carray sub 9 is j

1//new4.cpp

```
2// new also works with arrays of structures
3// new will return a pointer to an instance of the desired structure
4// type that you request.
5// If new returns NULL as the address of the new variable,
6//      then the dynamic memory allocation failed
7#include <iostream.h>
8
9struct XY
10{
11    int x;
12    float y;
13};
14
15main()
16{
17    int i;
18    struct XY * Xarray = new struct XY [10];
19
20    cout << "new returned " << Xarray << endl;
21    cout << "Size of X is " << sizeof(Xarray) << endl;
22    cout << "Size of *X is " << sizeof(*Xarray) << endl;
23
24    for ( i = 0; i < 10; i++ )
25    {
26        cout << "Address of Xarray sub " << i << " is "
27        << &Xarray[i] << endl;
28    }
29    cout << endl;
30}
31
32Output From Running Program
33new returned 0x181a1002
34Size of X is 2
35Size of *X is 6
36
37Address of Xarray sub 0 is 0x181a1002
38Address of Xarray sub 1 is 0x181a1008
39Address of Xarray sub 2 is 0x181a100e
40Address of Xarray sub 3 is 0x181a1014
41Address of Xarray sub 4 is 0x181a101a
42Address of Xarray sub 5 is 0x181a1020
43Address of Xarray sub 6 is 0x181a1026
44Address of Xarray sub 7 is 0x181a102c
45Address of Xarray sub 8 is 0x181a1032
46Address of Xarray sub 9 is 0x181a1038
47
```

```

1// new5.cpp
2// new also works with classes
3// new will return a pointer to an instance of the desired class type
4// that you request
5// if new returns NULL as the address of the new variable,
6//     then the dynamic memory allocation failed.
7
8#include <iostream.h>
9
10class XY
11{
12    private:
13        int x;
14        float y;
15    public:
16        XY();
17        void show_x_and_y();
18};
19
20// just slam some values in x and y
21// put in a cout to show when this thing is called
22// this will be very instructive when we are dealing with arrays
23XY::XY()
24{
25    cout << "XY no arg constructor called " << endl;
26    x = 10;
27    y = 11.1;
28}
29
30void XY::show_x_and_y()
31{
32    cout << "x is " << x << " y is " << y << endl;
33}
34
35main()
36{
37    XY * X = new XY;
38
39    cout << "Size of X is " << sizeof(X) << endl;
40    cout << "Size of *X is " << sizeof(*X) << endl;
41
42    // remember that the thing returned by new is a POINTER
43    X->show_x_and_y();
44}
45
46Output From Running Program
47XY no arg constructor called
48Size of X is 2
49Size of *X is 6
50x is 10 y is 11.1

```



```

1// new6.cpp
2// new also works with arrays of classes
3// new will return a pointer to an instance of the desired class type
4// that you request
5// if new returns NULL as the address of the new variable,
6//     then the dynamic memory allocation failed.
7#include <iostream.h>
8class XY
9{
10    private:
11        int x;
12        float y;
13        static int xval;    // use for differing init values
14        static float yval;
15    public:
16        XY();
17        void show_x_and_y();
18};
19
20int XY::xval = 0;
21float XY::yval = 0.0;
22
23// put in a cout to show when this thing is called
24// this will be very instructive when we are dealing with arrays
25XY::XY()
26{
27    cout << "XY no arg constructor called " << endl;
28    x = xval;
29    xval = xval + 1;
30    y = yval;
31    yval = yval + 1.0;
32}
33
34void XY::show_x_and_y()
35{
36    cout << "x is " << x << " y is " << y << endl;
37}
38
39main()
40{
41    int i;
42    XY * X = new XY[5];
43
44    cout << "Size of X is " << sizeof(X) << endl;
45    cout << "Size of *X is " << sizeof(*X) << endl;
46
47    for ( i = 0; i < 5; i++ )
48    {
49        // remember that the thing returned by new is a POINTER
50        X[i].show_x_and_y();
51    }
52}

```

1Output From Running Program
2XY no arg constructor called
3XY no arg constructor called
4XY no arg constructor called
5XY no arg constructor called
6XY no arg constructor called
7Size of X is 2
8Size of *X is 6
9x is 0 y is 0
10x is 1 y is 1
11x is 2 y is 2
12x is 3 y is 3
13x is 4 y is 4

```

1// new7.cpp
2// new also works with classes where other classes are embedded
3// new will return a pointer to an instance of the desired class type
4// that you request
5// if new returns NULL as the address of the new variable,
6//     then the dynamic memory allocation failed.
7
8#include <iostream.h>
9
10class XY
11{
12    private:
13        int x;
14        float y;
15        static int xval;           // use for differing init values
16        static float yval;
17    public:
18        XY();
19        void show_x_and_y();
20        void setxy(int,float);
21};
22
23int XY::xval = 0;
24float XY::yval = 0.0;
25
26// put in a cout to show when this thing is called
27// this will be very instructive when we are dealing with arrays
28XY::XY()
29{
30    cout << "XY no arg constructor called " << endl;
31    x = xval;
32    xval = xval + 1;
33    y = yval;
34    yval = yval + 1.0;
35}
36
37void XY::show_x_and_y()
38{
39    cout << "x is " << x << " y is " << y << endl;
40}
41
42void XY::setxy(int i, float f)
43{
44    x = i;
45    y = f;
46}

```

```

1// create a new class into which an instance of an XY class object will
2// be embedded. This will be interesting to watch in what order the
3// constructors are called.
4class AB
5{
6    private:
7        int a;
8        int b;
9        XY x1; // an XY is embedded in AB
10    public:
11        AB();
12        void show_ab();
13};
14
15AB::AB()
16{
17    cout << "AB no arg constructor called " << endl;
18    a = -1;
19    b = -2;
20    // at this point the no arg constructor was already called for x1
21    // we are CHANGING, not INITIALIZING the values for x and y of x1
22    x1.setxy(4,5.0);
23}
24
25void AB::show_ab()
26{
27    cout << "a is " << a << " b is " << b << endl;
28    x1.show_x_and_y(); // remember to use the public member function
29                        // x and y are private data of an XY that
30                        // is embedded, not inherited from.
31    cout << endl;
32}
33
34main()
35{
36    int i;
37    XY * X = new XY; // first create an instance of an XY It still works as we'd expect
38
39    cout << "Size of X is " << sizeof(X) << endl;
40    cout << "Size of *X is " << sizeof(*X) << endl;
41    X->show_x_and_y();
42    cout << endl << endl;
43
44    //now create an instance of an AB
45    // an XY will need to be created to complete the construction
46    // of the AB.
47    // Whose constructor will be called first? The AB or the XY?
48    AB * A = new AB;
49
50    cout << "Size of A is " << sizeof(A) << endl;
51    cout << "Size of *A is " << sizeof(*A) << endl;
52    A->show_ab();
53}

```

```
1XY no arg constructor called
2Size of X is 2
3Size of *X is 6
4x is 0 y is 0
5
6
7// the AB constructor is called, but before the first executable statement
8// of the AB constructor can be performed, ALL the memory for an instance
9// of an AB must be acquired, therefore the no argument version of the
10// XY constructor is invoked and that's why these prints occur in the
11// order that they do!
12XY no arg constructor called
13AB no arg constructor called
14Size of A is 2
15Size of *A is 10
16a is -1 b is -2
17x is 4 y is 5
18
```

```

1// new8.cpp
2// new also works with classes where inheritance is involved
3// new will return a pointer to an instance of the desired class type
4// that you request
5// if new returns NULL as the address of the new variable,
6//     then the dynamic memory allocation failed.
7
8#include <iostream.h>
9
10class XY
11{
12    private:
13        int x;
14        float y;
15        static int xval;    // use for differing init values
16        static float yval;
17    public:
18        XY();
19        void show_x_and_y();
20        void setxy(int,float);
21};
22
23int XY::xval = 0;
24float XY::yval = 0.0;
25
26// put in a cout to show when this thing is called
27// this will be very instructive when we are dealing with arrays
28XY::XY()
29{
30    cout << "XY no arg constructor called " << endl;
31    x = xval;
32    xval = xval + 1;
33    y = yval;
34    yval = yval + 1.0;
35}
36
37void XY::show_x_and_y()
38{
39    cout << "x is " << x << " y is " << y << endl;
40}
41
42void XY::setxy(int i, float f)
43{
44    x = i;
45    y = f;
46}

```

```

1// the MNO class will inherit from the XY class
2// again, all the memory for an MNO must be acquired before the first
3// executable statement of the MNO constructor can be run
4// therefore we will continue to be interested in the order in which
5// the XY constructors are called when creating MNO objects
6class MNO : public XY
7{
8    private:
9        int m,n,o;
10    public:
11        MNO();
12        void show_mno();
13};
14
15MNO::MNO()
16{
17    cout << "MNO no arg constructor was called " << endl;
18    m = -1;        n = -2;        o = -3;
19    // at this point we will change the values for x and y
20    // they have already been set in the XY constructor
21    cout << "Initial values of x and y are \n";
22    show_x_and_y();
23    setxy(24,35.0);
24    cout << "Post setxy values of x and y are \n";
25    show_x_and_y();
26}
27void MNO::show_mno()
28{
29    cout << "m is " << m << endl;
30    cout << "n is " << n << endl;
31    cout << "o is " << o << endl;
32    show_x_and_y();
33    cout << endl;
34}
35
36main()
37{
38    int i;
39    XY * X = new XY;    // first create an instance of an XY It still works as we'd expect
40    cout << "Size of X is " << sizeof(X) << endl;
41    cout << "Size of *X is " << sizeof(*X) << endl;
42    X->show_x_and_y();
43    cout << endl << endl;
44
45    //now create an instance of an MNO
46    // an XY will need to be created to complete the construction of the MNO.
47    // Whose constructor will be called first? The MNO or the XY?
48    MNO * M = new MNO;
49    cout << endl << endl;
50    cout << "Size of M is " << sizeof(M) << endl;
51    cout << "Size of *M is " << sizeof(*M) << endl;
52    M->show_mno();
53}

```

1Output From Running Program
2XY no arg constructor called
3Size of X is 2
4Size of *X is 6
5x is 0 y is 0
6
7
8XY no arg constructor called
9MNO no arg constructor was called
10Initial values of x and y are
11x is 1 y is 1
12Post setxy values of x and y are
13x is 24 y is 35
14
15
16Size of M is 2
17Size of *M is 12
18m is -1
19n is -2
20o is -3
21x is 24 y is 35
22


```

1// new9.cpp
2// new also works with arrays of classes where inheritance is involved
3// new will return a pointer to an instance of the desired class type
4// that you request
5// if new returns NULL as the address of the new variable,
6//     then the dynamic memory allocation failed.
7
8#include <iostream.h>
9
10class XY
11{
12    private:
13        int x;
14        float y;
15        static int xval;    // use for differing init values
16        static float yval;
17    public:
18        XY();
19        void show_x_and_y();
20        void setxy(int,float);
21};
22
23int XY::xval = 0;
24float XY::yval = 0.0;
25
26// put in a cout to show when this thing is called
27// this will be very instructive when we are dealing with arrays
28XY::XY()
29{
30    cout << "XY no arg constructor called " << endl;
31    x = xval;
32    xval = xval + 1;
33    y = yval;
34    yval = yval + 1.0;
35}
36
37void XY::show_x_and_y()
38{
39    cout << "x is " << x << " y is " << y << endl;
40}
41
42void XY::setxy(int i, float f)
43{
44    x = i;
45    y = f;
46}

```

```

1// the MNO class will inherit from the XY class
2// again, all the memory for an MNO must be acquired before the first
3// executable statement of the MNO constructor can be run
4// therefore we will continue to be interested in the order in which
5// the XY constructors are called when creating MNO objects
6
7class MNO : public XY
8{
9    private:
10        int m,n,o;
11    public:
12        MNO();
13        void show_mno();
14};
15
16MNO::MNO()
17{
18    cout << "MNO no arg constructor was called " << endl;
19    m = -1;
20    n = -2;
21    o = -3;
22    // at this point we will change the values for x and y
23    // they have already been set in the XY constructor
24    cout << "Initial values of x and y are \n";
25    show_x_and_y();
26    setxy(24,35.0);
27    cout << "Post setxy values of x and y are \n";
28    show_x_and_y();
29}
30
31void MNO::show_mno()
32{
33    cout << "m is " << m << endl;
34    cout << "n is " << n << endl;
35    cout << "o is " << o << endl;
36    show_x_and_y();
37    cout << endl;
38}

```

```

1main()
2{
3    int i;
4    XY * X = new XY;      // first create an instance of an XY It still works as we'd expect
5
6    cout << "Size of X is " << sizeof(X) << endl;
7    cout << "Size of *X is " << sizeof(*X) << endl;
8    X->show_x_and_y();
9    cout << endl << endl;
10
11    //now create an instance of an MNO
12    // an XY will need to be created to complete the construction
13    // of the MNO.
14    // Whose constructor will be called first? The MNO or the XY?
15    MNO * M = new MNO;
16    cout << endl << endl;
17
18    cout << "Size of M is " << sizeof(M) << endl;
19    cout << "Size of *M is " << sizeof(*M) << endl;
20    M->show_mno();
21
22    // now create an array of MNOs
23    MNO * Marray = new MNO[5];
24    cout << endl << endl;
25
26    cout << "Size of Marray is " << sizeof(Marray) << endl;
27    cout << "Size of *Marray is " << sizeof(*Marray) << endl;
28
29    for ( i = 0; i < 5; i++ )
30        Marray[i].show_mno();
31}

```

1Output From Running Program
2XY no arg constructor called
3Size of X is 2
4Size of *X is 6
5x is 0 y is 0
6
7
8XY no arg constructor called
9MNO no arg constructor was called
10Initial values of x and y are
11x is 1 y is 1
12Post setxy values of x and y are
13x is 24 y is 35
14
15
16Size of M is 2
17Size of *M is 12
18m is -1
19n is -2
20o is -3
21x is 24 y is 35
22
23XY no arg constructor called
24MNO no arg constructor was called
25Initial values of x and y are
26x is 2 y is 2
27Post setxy values of x and y are
28x is 24 y is 35
29XY no arg constructor called
30MNO no arg constructor was called
31Initial values of x and y are
32x is 3 y is 3
33Post setxy values of x and y are
34x is 24 y is 35
35XY no arg constructor called
36MNO no arg constructor was called
37Initial values of x and y are
38x is 4 y is 4
39Post setxy values of x and y are
40x is 24 y is 35
41XY no arg constructor called
42MNO no arg constructor was called
43Initial values of x and y are
44x is 5 y is 5
45Post setxy values of x and y are
46x is 24 y is 35
47XY no arg constructor called
48MNO no arg constructor was called
49Initial values of x and y are
50x is 6 y is 6
51Post setxy values of x and y are
52x is 24 y is 35
53

1Size of Marray is 2
2Size of *Marray is 12
3m is -1
4n is -2
5o is -3
6x is 24 y is 35
7
8m is -1
9n is -2
10o is -3
11x is 24 y is 35
12
13m is -1
14n is -2
15o is -3
16x is 24 y is 35
17
18m is -1
19n is -2
20o is -3
21x is 24 y is 35
22
23m is -1
24n is -2
25o is -3
26x is 24 y is 35
27

```

1// new10.cpp
2// new is an operator
3// operators may be overloaded
4// therefore new may be overloaded
5// WARNING, THIS PROGRAM WORKS DIFFERENTLY AND NEEDS DIFFERENT #INCLUDES
6// ON DIFFERENT OPERATING SYSTEMS. THIS VERSION IS FOR DOS PCs
7#include <iostream.h>
8#include <stddef.h>
9#include <stdlib.h>
10
11class XY
12{
13    private:
14        int x;
15        float y;
16    public:
17        XY();
18        XY(int);
19        void show_x_and_y();
20        void setxy(int,float);
21        void * operator new(size_t);
22        void * operator new(size_t,int);
23        void * operator new(size_t,int,int);
24};
25
26// put in a cout to show when this thing is called
27// this will be very instructive when we are dealing with arrays
28XY::XY()
29{
30    cout << "XY no arg constructor called " << endl;
31    x = 10;
32    y = 11.1;
33}
34
35XY::XY(int i)
36{
37    cout << "XY one arg constructor called " << endl;
38    x = i;
39    y = 999.999;
40}
41
42void XY::show_x_and_y()
43{
44    cout << "x is " << x << " y is " << y << endl;
45}
46
47void XY::setxy(int i, float f)
48{
49    x = i;
50    y = f;
51}

```

```

1// this is a new and interesting thing to do
2// we are taking over the new function for the XY class
3// taking over new for this class in NO WAY affects new for any other class
4void * XY::operator new (size_t size_of_item)
5{
6    // for the listed number of items, invoke the constructor
7    cout << "The new(size_t) operator for XY class was invoked\n";
8    cout << "size_of_item was " << size_of_item << endl;
9
10   // we are going to allocate enough memory here
11   cout << "Calling malloc.... ";
12   XY * ptr = ( XY*) malloc (size_of_item);
13   cout << "Back from malloc\n";
14
15   // we are going to pass a pointer to the memory to the constructor
16   // the next statement executed after this one will be the first
17   // executable statement of the constructor
18   return ( ptr );
19}
20
21// now we are going to provide a polymorphic version of the new operator
22// remember this affects only new for the XY class, not any other class
23// the new function will be called to get the memory and then the
24// constructor will be invoked
25void * XY::operator new(size_t size_of_item, int arg1 )
26{
27    cout << "The new(size_t,int) operator for XY class was invoked\n";
28    cout << "size_of_item was " << size_of_item << endl;
29    cout << "arg1 is " << arg1 << endl;
30    XY * ptr = (XY*) malloc (size_of_item);
31    return NULL;
32}
33
34// now we are going to provide another polymorphic version of the new operator
35// remember this affects only new for the XY class, not any other class
36// the new function will be called to get the memory and then the
37// constructor will be invoked
38void * XY::operator new(size_t size_of_item, int arg1, int arg2 )
39{
40    cout << "The new(size_t,int,int) operator for XY class was invoked\n";
41    cout << "size_of_item was " << size_of_item << endl;
42    cout << "arg1 is " << arg1 << endl;
43    cout << "arg2 is " << arg2 << endl;
44    XY * ptr = (XY*) malloc (size_of_item);
45    return NULL;
46}

```

```

1main()
2{
3    int i;
4
5    cout << "AAAAA" << endl;
6    // the one argument new operator will be called
7    // the one argument will be the size of an XY
8    XY * X1 = new XY;           // first create an instance of an XY
9    cout << "Size of X1 is " << sizeof(X1) << endl;
10   cout << "Size of *X1 is " << sizeof(*X1) << endl;
11   X1->show_x_and_y();
12   cout << endl << endl;
13
14
15   cout << "BBBBB" << endl;
16   // the one argument new operator will be called
17   // the one argument will be the size of an XY
18   XY * X2 = new XY(4);        // cause one arg constructor to be called
19   cout << "Size of X2 is " << sizeof(X2) << endl;
20   cout << "Size of *X2 is " << sizeof(*X2) << endl;
21   X2->show_x_and_y();
22   cout << endl << endl;
23
24
25   // this will NOT cause any of our new operator functions to be called
26   // WHY?
27   // Because C++ has a global new operator that is used for allocation
28   // of memory for arrays and we don't take it over
29   cout << "CCCCC" << endl;
30   XY * X3 = new XY[3];        // no initializers can be specified for arrays
31   cout << "Size of X3 is " << sizeof(X3) << endl;
32   cout << "Size of *X3 is " << sizeof(*X3) << endl;
33   X3[0].show_x_and_y();
34   X3[1].show_x_and_y();
35   X3[2].show_x_and_y();
36   cout << endl << endl;
37
38
39
40   cout << "DDDDD" << endl;
41   // the 1 will be passed in as arg1 to the two arg new operator
42   // the 4 will be translated to 4*sizeof(XY) and passed as the first arg
43   XY * X4 = new (1) XY[4];
44   cout << "Size of X4 is " << sizeof(X4) << endl;
45   cout << "Size of *X4 is " << sizeof(*X4) << endl;
46   X4[0].show_x_and_y();
47   X4[1].show_x_and_y();
48   X4[2].show_x_and_y();
49   X4[3].show_x_and_y();
50   cout << endl << endl;

```



```
1      cout << "EEEEEE" << endl;
2      // the 10 will be passed in as arg1 to the two arg new operator
3      // the 20 will be passed in as arg2 to the two arg new operator
4      // the 5 will be translated to 5*sizeof(XY) and passed as the first arg
5      XY * X5 = new (10,20) XY[5];
6      cout << "Size of X5 is " << sizeof(X5) << endl;
7      cout << "Size of *X5 is " << sizeof(*X5) << endl;
8      X5[0].show_x_and_y();
9      X5[1].show_x_and_y();
10     X5[2].show_x_and_y();
11     X5[3].show_x_and_y();
12     X5[4].show_x_and_y();
13     cout << endl << endl;
14 }
```

```

1Output From Running Program
2AAAAAA
3The new(size_t) operator for XY class was invoked
4size_of_item was 6
5Calling malloc.... Back from malloc
6XY no arg constructor called
7Size of X1 is 2
8Size of *X1 is 6
9x is 10 y is 11.1
10
11
12BBBBBB
13The new(size_t) operator for XY class was invoked
14size_of_item was 6
15Calling malloc.... Back from malloc
16XY one arg constructor called
17Size of X2 is 2
18Size of *X2 is 6
19x is 4 y is 999.999023
20
21
22CCCCC
23XY no arg constructor called
24XY no arg constructor called
25XY no arg constructor called
26Size of X3 is 2
27Size of *X3 is 6
28x is 10 y is 11.1
29x is 10 y is 11.1
30x is 10 y is 11.1
31
32
33DDDDDD
34The new(size_t,int) operator for XY class was invoked
35size_of_item was 24
36arg1 is 1
37The new(size_t) operator for XY class was invoked
38size_of_item was 6
39Calling malloc.... Back from malloc
40XY no arg constructor called
41XY no arg constructor called
42XY no arg constructor called
43XY no arg constructor called
44Size of X4 is 2
45Size of *X4 is 6
46x is 0 y is 2.687419e+32
47x is 10 y is 11.1
48x is 10 y is 11.1
49x is 10 y is 11.1
50

```

1EEEEEE
2The new(size_t,int,int) operator for XY class was invoked
3size_of_item was 30
4arg1 is 10
5arg2 is 20
6The new(size_t) operator for XY class was invoked
7size_of_item was 6
8Calling malloc.... Back from malloc
9XY no arg constructor called
10XY no arg constructor called
11XY no arg constructor called
12XY no arg constructor called
13XY no arg constructor called
14Size of X5 is 2
15Size of *X5 is 6
16x is 0 y is 2.687419e+32
17x is 10 y is 11.1
18x is 10 y is 11.1
19x is 10 y is 11.1
20x is 10 y is 11.1

Section 9

2

3This section is about C++ i/o.

4Many C++ programmers just do C i/o and are quite happy.

5However, C++ does introduce some new concepts which can be useful.

6C++ provides persistent and non persistent formatting of output.

7C++ provides different ways to interpret input streams.

8C++ provides various methods to open files, via open calls or via constructors.

9C++ allows the user to take over the i/o operators for user defined classes and thus remove the need for the
10programmer to learn special i/o subroutines to use your class.

11

12This chapter also covers the file error handling and file controlling bits of C++

13

14coutcin.cpp this program illustrates very simple usage of cout and cin

15

16coutfmt1.cpp do some fundamental formatting using cout

17

18coutfmt2.cpp the use of ios flags for formatting using cout

19

20coutfmt3.cpp persistence of formatting

21

22coutfmt4.cpp width and justification

23

24flushit.cpp the buffering of output, the separate buffers of printf and cout

25

26testws.cpp the treatment of whitespace characters and the skipws ios flag

27

28ostream1.cpp ostream functions tellp flush put write

29

30ostream2.cpp ostream flags

31

32ostream3.cpp ostream flags and functions, good, eof, fail, bad, clear

33

34istream1.cpp istream functions get, peek, putback, read, getline, seekg, tellg

35

36istream2.cpp istream flags

37

38istream3.cpp istream flags and functions, good, bad, fail, clear

39

40finfout.cpp file io

41

42finfout1.cpp file io

43

44finfout2.cpp file io

45

46finfout3.cpp file io

47

48ostristr.cpp stream status

49

50predefs.cpp predefined C++ streams cout, cin, cerr, clog

51

52filebit1.cpp filebit1.dat filebit1.out fstream bits

53

54filebit2.cpp filebit2.dat filebit2.out fstream bits and functions

55

1fileop1.cpp	file operations
2	
3fileop2.cpp	file open methods

1// coutcin.cpp

```
2// C++ allows the programmer to use printf, scanf and other stdio.h routines
3// C++ also provides new input, output and error processing abilities
4// C++ introduces the concept of a stream
5// You place things in an output stream
6// Putting things in an output stream is a binary operation that requires
7// the name of the stream to be written to and the object to be written
8// the operation returns a reference to the stream written to
9
10// You take things from an input stream
11// Taking things from an input stream is a binary operation that requires
12// the name of the stream to be read from and a location to write the input
13// object into.
14
15// The default C++ output stream is named cout
16// The default C++ input stream is named cin
17// The user gains access to cout and cin through iostream.h
18
19#include <stdio.h>           // get printf and scanf
20#include <iostream.h>       // get cout and cerr
21
22main()
23{
24    int i = 0;
25
26    // use the i/o routines from stdio.h
27    printf("Value for i please? "); // printf is a function
28    scanf("%i",&i);                // scanf is a function
29    printf("i is %i\n",i);
30    printf("\n");
31
32    cout << "Input a value for i please \n"; // cout is not a function
33    // cout is a STREAM. Specifically it is an ostream object
34    // an output stream object.
35    // It accepts things to be printed, strings, integers, chars ...
36    // we place the string "Input a value for i please\n" in the stream
37    // using the binary operator <<
38    // The << operator, when used with an ostream object, like cout
39    // passes the item on its right to the ostream object on its left.
40    // The operation returns an ostream operator to allow for chaining.
41
42    cin >> i; // cin is not a function
43    // cin is a STREAM. Specifically it is an istream object
44    // an input stream object.
45    // It reads in things and puts them in the specified place
46    // The >> operator, when used with an istream object, like cin
47    // passes a value from the istream on the left to the variable
48    // on the right. The operation returns an istream operator to allow
49    // for chaining.
```

```
1      cout << "You entered " << i << " \n";          // chaining
2      // note that no formatting informatino about i was provided
3      // in printf we would have to specify a format like %i or %o
4      // the cout stream has default formats for each data type
5      // in C++, each variable knows its type at run time, therefore
6      // information about i, an integer, does not have to be passed
7      // explicitly to the cout stream.
8      cout << "\n";
9}
10
11Output From Running Program
12coutcin.out
13
14Value for i please? i is 4
15
16Input a value for i please
17You entered 12
```

1// coutfmt1.cpp

```
2// this program illustrates some formatting of output
3// C allows the printf function to use %i %5i %05i to control width and fill
4// C allows the printf function to use %f %.2f %7.2f to control width and fill
5// C allows the printf function to use %i %o %x to control base
6
7// cout is not a function, it is an ostream object
8// The object maintains information about width, fill, padding, justification
9// We can tell the cout object to change state via messages that we send it
10// Some messages that we send are "enumerated types" hex, oct, dec, endl, ends
11// Some messages that we send are "non-enumerated types"
12// setw, setprecision, setbase, setfill, setiosflags, resetiosflags
13
14#include <stdio.h>
15#include <iostream.h>           // get access to the cout and cin objects
16#include <iomanip.h>           // get access to modifiers for cout cin objects
17main()
18{
19    int i = 13; int j = 15; int k = 7;
20
21    // C and C++ both print integers by default in base ten
22    printf("i = %i\n",i); cout << "i = " << i << endl;
23
24    // the %i %o %x indicates what base to print i in
25    printf("i base 10 %i base 8 %o base 16 %x\n",i,i,i);
26
27    // the dec, oct, hex tells the cout object in what base to prints ints
28    cout << "i base 10 " << dec << i << endl;
29    cout << "i base 8 " << oct << i << endl;
30    cout << "i base 16 " << hex << i << endl;
31
32    // In C, you need to specify the base for each integer printed
33    // In C++, once you've established a base for ints, it remains in
34    // effect until you change it
35    cout << hex;
36    cout << "A1 i " << i << "\tj " << j << "\tk " << k << endl;
37    cout << "A2 i " << i << "\tj " << j << "\tk " << k << endl;
38    cout << oct;
39    cout << "A3 i " << i << "\tj " << j << "\tk " << k << endl;
40    cout << "A4 i " << i << "\tj " << j << "\tk " << k << endl;
41    cout << dec;
42    cout << "i " << i << endl; cout << "j " << j << endl;
43    cout << "k " << k << endl;
44
45    // In C you may specify the width and precision for each float that
46    // you want to print, in C++ you may specify the width and precision
47    // for each field that you want to print
48    float f = 1.234; float g = 111.23456; float h = 11111.23;
```



```

1 // C and C++ both have a default width and precision for floats
2 printf("f = %f\n",f); cout << "f = " << f << endl;
3
4 printf("f %f %7.2f\t g %.5f %12.6f\t h %f %4.1f\n",f,f,g,g,h,h);
5 cout << "AAA f " << setw(20) << setprecision(5) << f << endl;
6 cout << "AAA g " << setw(10) << setprecision(15) << f << endl;
7 cout << "AAA h " << setw(40) << setprecision(25) << f << endl;
8
9 cout << "f " << setw(20) << setprecision(7) << setfill(65) <<
10 f << endl;
11}

```

```

1Output From Running Program
2coutfmt1.out
3
4i = 13          from first printf and cout
5i = 13
6
7i base 10 13 base 8 15 base 16 d
8i base 10 13
9i base 8 15
10i base 16 d
11
12A1 i d j f k 7
13A2 i d j f k 7
14A3 i 15 j 17 k 7
15A4 i 15 j 17 k 7
16
17i 13
18j 15
19k 7
20
21f = 1.234
22f = 1.234000
23
24AAA f          1.234
25AAA g 1.233999967575073
26AAA h          1.2339999675750732421875
27
28f 1.234000 1.23 g 111.23456 111.234558 h 11111.230469 11111.2
29
30f AAAAAAAAAAAAAAAAAA1.234
31

```

1// coutfmt2.cpp

```
2// this program illustrates some more formatting of output
3
4#include <stdio.h>
5#include <iostream.h>    // get access to the cout and cin objects
6#include <iomanip.h>      // get access to modifiers for cout cin objects
7main()
8{
9
10     float f = 1.2;
11     float g = 12.345;
12     float h = 123;
13
14     // left justify output
15     cout << "Left Justify \n";
16     cout.unsetf(ios::right);
17     cout.unsetf(ios::internal);
18     cout.setf(ios::left);
19     cout << setw(10) << f
20         << setw(10) << g
21         << setw(10) << h << endl;
22
23     // right justify output
24     cout << "\n\nRight Justify \n";
25     cout.unsetf(ios::left);
26     cout.unsetf(ios::internal);
27     cout.setf(ios::right);
28     cout << setw(10) << f
29         << setw(10) << g
30         << setw(10) << h << endl;
31
32     // "internal" justify output
33     cout << "\n\nInternal Justify \n";
34     cout.unsetf(ios::left);
35     cout.unsetf(ios::right);
36     cout.setf(ios::internal);
37     cout << setw(10) << f
38         << setw(10) << g
39         << setw(10) << h << endl;
40
41}
```

1Output From Running Program
2Left Justify
31.2 12.345 123
4
5
6Right Justify
7 1.2 12.345 123
8
9
10Internal Justify
11 1.2 12.345 123
12

1// coutfmt3.cpp

```
2// this program illustrates some more formatting of output
3#include <stdio.h>
4#include <iostream.h>    // get access to the cout and cin objects
5#include <iomanip.h>      // get access to modifiers for cout cin objects
6main()
7{
8    int i = 13; int j = 15; int k = 7;
9
10   // these displays will use defaults with respect to whether
11   // letters are printed upper or lower case    ios::uppercase
12   // signs are added in front of positive numbers ios::showpos
13   // any indication of base is given           ios::showbase
14
15   // the dec, oct, hex tells the cout object in what base to prints ints
16   cout << "BEFORE SETTING uppercase, showbase, showpos\n";
17   cout << "i base 10 " << dec << i << endl;
18   cout << "i base 8  " << oct << i << endl;
19   cout << "i base 16 " << hex << i << endl;
20
21   // In C++, once you've established a base for ints, it remains in
22   // effect until you change it
23   cout << hex;
24   cout << "A1 i " << i << "\tj " << j << "\tk " << k << endl;
25   cout << "A2 i " << i << "\tj " << j << "\tk " << k << endl;
26   cout << oct;
27   cout << "A3 i " << i << "\tj " << j << "\tk " << k << endl;
28   cout << "A4 i " << i << "\tj " << j << "\tk " << k << endl;
29   cout << dec;
30   cout << "A5 i " << i << endl; cout << "j " << j << endl;
31   cout << "A6 k " << k << endl;
32
33   // NOW I WILL CHANGE THE  uppercase, showpos, showbase, fields
34   cout.setf(ios::uppercase);
35   cout.setf(ios::showbase);
36   cout.setf(ios::showpos);
37   cout << "AFTER SETTING uppercase, showbase, showpos\n";
38   cout << "i base 10 " << dec << i << endl;
39   cout << "i base 8  " << oct << i << endl;
40   cout << "i base 16 " << hex << i << endl;
41
42   // In C++, once you've established a base for ints, it remains in effect until you change it
43   cout << hex;
44   cout << "B1 i " << i << "\tj " << j << "\tk " << k << endl;
45   cout << "B2 i " << i << "\tj " << j << "\tk " << k << endl;
46   cout << oct;
47   cout << "B3 i " << i << "\tj " << j << "\tk " << k << endl;
48   cout << "B4 i " << i << "\tj " << j << "\tk " << k << endl;
49   cout << dec;
50   cout << "B5 i " << i << endl; cout << "j " << j << endl;
51   cout << "B6 k " << k << endl;
52}
```

```

1Output From Running Program
2BEFORE SETTING uppercase, showbase, showpos
3i base 10 13
4i base 8 15
5i base 16 d
6A1 i d j f k 7
7A2 i d j f k 7
8A3 i 15 j 17 k 7
9A4 i 15 j 17 k 7
10A5 i 13
11j 15
12A6 k 7
13AFTER SETTING uppercase, showbase, showpos
14i base 10 +13
15i base 8 015
16i base 16 0XD
17B1 i 0XD j 0XF k 0X7
18B2 i 0XD j 0XF k 0X7
19B3 i 015j 017 k 07
20B4 i 015j 017 k 07
21B5 i +13
22j +15
23B6 k +7
24

```

1// coutfmt4.cpp

```
2// this program illustrates some more formatting of output
3
4#include <stdio.h>
5#include <iostream.h>    // get access to the cout and cin objects
6#include <iomanip.h>      // get access to modifiers for cout cin objects
7main()
8{
9
10     float f = 1.2;
11     float g = 12.345;
12     float h = 123;
13
14     cout << "Default Output \n";
15     cout << f << "\t" << g << "\t" << h << endl;
16
17     cout << "\nWith width 10 and right justify specified\n";
18     cout.unsetf(ios::left);
19     cout.setf(ios::right);
20     cout << setw(10) << f << "\t" <<
21     setw(10) << g << "\t" <<
22     setw(10) << h << endl;
23
24     cout << "\nWith width 10 and left justify specified\n";
25     cout.unsetf(ios::right);
26     cout.setf(ios::left);
27     cout << setw(10) << f << "\t" <<
28     setw(10) << g << "\t" <<
29     setw(10) << h << endl;
30
31     cout << "\nWith showpoint, no width and right justify set\n";
32     cout.unsetf(ios::left);
33     cout.setf(ios::right);
34     cout.setf(ios::showpoint);
35     cout << f << "\t" << g << "\t" << h << endl;
36
37     cout << "\nWith width 10 and showpoint specified\n";
38     cout << setw(10) << f << "\t" <<
39     setw(10) << g << "\t" <<
40     setw(10) << h << endl;
41}
```

```

1Output From Running Program
2Default Output
31.2      12.345  123
4
5With width 10 and right justify specified
6   1.2    12.345      123
7
8With width 10 and left justify specified
91.2      12.345      123
10
11With showpoint, no width and right justify set
121.200000      12.345000      123.000000
13
14With width 10 and showpoint specified
15 1.200000      12.345000      123.000000
16

```


1// flushit.cpp

```
2
3// you need to compile and run this program to SEE the differences
4// that buffering may or may not make in your system
5
6// this program shows you how to manipulate, by either using the default
7// mechanism, forcing buffering on, or forcing buffering off, the buffering
8// mechanism that your system wants to use
9
10// Both C and C++ will have their output buffered in certain situations
11// You can force the output to be displayed immediately by FLUSHing the
12// output buffer. If you are going to use printf and cout in the same
13// program, you need to be very careful to flush after each statement.
14// This is because printf and cout have seperate buffers that may fill
15// and be dumped by the system at different rates and thus the sequence of
16// printf's and cout's that you wrote may not display in that sequence
17
18#include <stdio.h>
19#include <iostream.h>
20#include <dos.h>          // this line is operating system dependant
21main()
22{
23    int i;
24
25    // this loop will use the default buffering that your system uses
26
27    // this loop should produce output of
28    // printf cout printf cout printf cout printf cout
29    // on some systems it will print
30    // printf printf printf printf cout cout cout
31    // on other systems, it will mix them up in an undetermined way
32    // on some systems they will be printed at one second intervals
33    // on other systems they won't be displayed until the flushing
34    // endl and cr are output
35
36    // the point of this section is that if you are going to do output
37    // you have to remember that it is buffered and that unexplained
38    // output results can often be explained by examining the buffering
39    // mechanism that your compiler and operating system use
40    for ( i = 0; i < 4; i++ )
41    {
42        printf(" printf ");
43        cout << " cout ";          // put cout in the output buffer
44        sleep(1);                  // wait a second
45    }
46    printf("\n");
47    cout << endl;
```

```

1 // cout has two functions unsetf and setf which are used to manipulate
2 // the state of certain bits that control its behaviour
3 // unsetf clears a flag
4 // setf sets a flag
5 // the flag ios::unitbuf, when set, forces all streams to be flushed
6 // immediately after anything is inserted into them
7 // the flag ios::stdio, when set, forces stdout and stderr to be
8 // flushed immediately after anything is inserted into them
9
10 cout.unsetf(ios::unitbuf); // turn off buffer flushing
11 cout.unsetf(ios::stdio); // turn off buffer flushing
12
13 for ( i = 0; i < 4; i++ )
14 {
15     printf(" printf ");
16     cout << " cout "; // put cout in the output buffer
17     sleep(1); // wait a second
18 }
19 printf("\n");
20 cout << endl << endl;
21
22 // this loop should produce output of
23 // printf cout printf cout printf cout printf cout
24 // this loop explicitly flushes the buffers that it is writing to
25 // the standard output buffer is flushed with fflush
26 // the ostream buffer is flushed using the cout reserved word flush
27 // a carriage return or an endl would have the same result
28 for ( i = 0; i < 4; i++ )
29 {
30     printf(" printf "); // put printf in the output buffer
31     fflush(stdout);
32     cout << " cout " << flush; // put cout in the output buffer
33     sleep(1); // wait a second
34 }
35 printf("\n");
36 cout << endl;
37}

```

```
1Output From Running Program To Output File
2 cout cout cout cout
3 cout cout cout cout
4
5 printf printf printf printf
6 printf printf printf printf
7 printf cout printf cout printf cout printf cout
8
9
10
11Screen Dump From Running To Screen
12 printf cout printf cout printf cout printf cout
13
14 printf printf printf printf
15 cout cout cout cout
16
17 printf cout printf cout printf cout printf cout
```

1// testws.cpp

```
2// this program demonstrates the difference between doing input with cin
3// and the default setup versus doing input with cin with skips specified
4#include <iostream.h>
5main()
6{
7    char a,b,c;
8    int i,j,k;
9
10   // this line tells the system NOT to ignore white space characters
11   // on input
12   cin.setf(ios::skipws);
13
14   cout << "Enter three characters with no spaces between them\n";
15   cin >> a >> b >> c ;
16   cout << "You entered " << a << " " << b << " " << c << endl;
17
18   cout << "Enter three characters with some spaces between them\n";
19   cin >> a >> b >> c ;
20   cout << "You entered " << a << " " << b << " " << c << endl;
21
22   cout << "Enter three integers with spaces between them\n";
23   cin >> i >> j >> k ;
24   cout << "You entered " << i << " " << j << " " << k << endl;
25
26   // this line tells the system TO ignore white space characters on input
27   cin.unsetf(ios::skipws);
28
29   cout << "Enter three characters with no spaces between them\n";
30   cin >> a >> b >> c ;
31   cout << "You entered " << a << " " << b << " " << c << endl;
32
33   cout << "Enter three characters with some spaces between them\n";
34   cin >> a >> b >> c ;
35   cout << "You entered " << a << " " << b << " " << c << endl;
36
37   cout << "Enter three integers with spaces between them\n";
38   cin >> i >> j >> k ;
39   cout << "You entered " << i << " " << j << " " << k << endl;
40}
```

1Output From Running Program
2Enter three characters with no spaces between them
3You entered a b c
4Enter three characters with some spaces between them
5You entered a b c
6Enter three integers with spaces between them
7You entered 1 2 3
8Enter three characters with no spaces between them
9You entered
10 a b
11Enter three characters with some spaces between them
12You entered c
13Enter three integers with spaces between them
14You entered 1 2 3
15

```

1// ostream1.cpp
2
3// the ostream class provides some useful functions
4// flush()          to clear the output buffer
5// put()            to print one character
6// write()          to print many characters
7// tellp()          where is the output pointer?
8
9#include <iostream.h>
10
11char s[] = {"This is a message"};
12
13main()
14{
15    int i,j,k,l;
16
17    i = cout.tellp();
18    cout.put('A');
19    cout.put('B');
20    cout.put('C');
21    cout.put('D');
22    cout.flush();
23
24    j = cout.tellp();
25    cout.write("XXXX",4);
26    cout.flush();
27
28    k = cout.tellp();
29    cout.write(s,sizeof(s) );
30    l = cout.tellp();
31    cout.flush();
32
33    cout << endl << endl;
34    cout << "Before ABCD The output stream pointer was at "
35         << i << endl;
36    cout << "Before XXX The output stream pointer was at "
37         << j << endl;
38    cout << "Before s the output stream pointer was at "
39         << k << endl;
40    cout << "After s the output stream pointer was at "
41         << l << endl;
42}

```

1Output From Running Program
2
3ABCDXXXXThis is a message
4
5Before ABCD The output stream pointer was at 0
6Before XXX The output stream pointer was at 4
7Before s the output stream pointer was at 8
8After s the output stream pointer was at 26
9ABCDXXXXThis is a message
10
11Before ABCD The output stream pointer was at 216
12Before XXX The output stream pointer was at 220
13Before s the output stream pointer was at 224
14After s the output stream pointer was at 242
15ABCDXXXXThis is a message
16
17Before ABCD The output stream pointer was at 439
18Before XXX The output stream pointer was at 443
19Before s the output stream pointer was at 447
20After s the output stream pointer was at 465
21ABCDXXXXThis is a message
22
23Before ABCD The output stream pointer was at 662
24Before XXX The output stream pointer was at 666
25Before s the output stream pointer was at 670
26After s the output stream pointer was at 688
27ABCDXXXXThis is a message
28
29Before ABCD The output stream pointer was at 885
30Before XXX The output stream pointer was at 889
31Before s the output stream pointer was at 893
32After s the output stream pointer was at 911

1// ostream2.cpp

```
2// the ostream has a number of flags that control it
3// they can be read as a group
4// they can be queried individually to return a true/false answer
5#include <iostream.h>
6
7main()
8{
9    long int first_flags = 0;
10   long int second_flags = 0;
11   int i;
12   long int j = 0;
13   long int k = 0;
14   char c;
15
16   first_flags = cout.flags();
17   cout << "The default value of the flags for cout is: ";
18   cout << hex << first_flags << endl;
19
20   cout.setf(ios::hex);
21   cout.setf(ios::showbase);
22
23   cout << "Bit for skipws is \t" << ios::skipws << endl;
24   cout << "Bit for left is \t" << ios::left << endl;
25   cout << "Bit for right is \t" << ios::right << endl;
26   cout << "Bit for internal is \t" << ios::internal << endl;
27   cout << "Bit for dec is \t" << ios::dec << endl;
28   cout << "Bit for oct is \t" << ios::oct << endl;
29   cout << "Bit for hex is \t" << ios::hex << endl;
30   cout << "Bit for showbase is \t" << ios::showbase << endl;
31   cout << "Bit for showpoint is \t" << ios::showpoint << endl;
32   cout << "Bit for scientific is \t" << ios::scientific << endl;
33   cout << "Bit for fixed is \t" << ios::fixed << endl;
34   cout << "Bit for unitbuf is \t" << ios::unitbuf << endl;
35   cout << "Bit for stdio is \t" << ios::stdio << endl;
36
37   second_flags = cout.flags();
38   cout << "The value of the flags for cout is: ";
39   cout << hex << second_flags << endl;
40
41   j = cout.width();
42   cout << "The value of the width for cout is: ";
43   cout << dec << j << endl;
44
45   k = cout.precision();
46   cout << "The value of the precision for cout is: ";
47   cout << dec << k << endl;
48
49   c = cout.fill();
50   i = (int) c;
51   cout << "The value of the fill for cout is: ";
52   cout << hex << i << endl;
53}
```


1Output From Running Program
2The default value of the flags for cout is: 1
3Bit for skipws is 0x1
4Bit for left is 0x2
5Bit for right is 0x4
6Bit for internal is 0x8
7Bit for dec is 0x10
8Bit for oct is 0x20
9Bit for hex is 0x40
10Bit for showbase is 0x80
11Bit for showpoint is 0x100
12Bit for scientific is 0x800
13Bit for fixed is 0x1000
14Bit for unitbuf is 0x2000
15Bit for stdio is 0x4000
16The value of the flags for cout is: 0xc1
17The value of the width for cout is: 0
18The value of the precision for cout is: 0
19The value of the fill for cout is: 0x20
20

1// ostream3.cpp

```
2// the ostream has a number of flags that report its status
3// they can be read as a group
4// they can be queried individually to return a true/false answer
5
6#include <iostream.h>
7
8main()
9{
10     long int first_state = 0;
11     int i,j,k,l,m,n;
12
13     first_state = cout.rdstate();
14     cout << "The default value of the state for cout is: ";
15     cout << hex << first_state << endl;
16
17     cout.setf(ios::hex);
18     cout.setf(ios::showbase);
19
20     cout << "Bit for goodbit is  \t" << ios::goodbit << endl;
21     cout << "Bit for eofbit is  \t" << ios::eofbit << endl;
22     cout << "Bit for failbit is  \t" << ios::failbit << endl;
23     cout << "Bit for badbit is  \t" << ios::badbit << endl;
24     cout << "Bit for hardfail is  \t" << ios::hardfail << endl;
25
26     j = cout.good();
27     cout << "The value of good for cout is: ";
28     cout << dec << j << endl;
29
30     k = cout.eof();
31     cout << "The value of eof for cout is: ";
32     cout << dec << k << endl;
33
34     l = cout.fail();
35     cout << "The value of fail for cout is: ";
36     cout << dec << l << endl;
37
38     m = cout.bad();
39     cout << "The value of bad for cout is: ";
40     cout << dec << m << endl;
41
42     // if the ostream gets into a bad state, you can attempt to
43     // clear it using
44     cout.clear();
45}
```

1Output From Running Program

2

3The default value of the state for cout is: 0

4Bit for goodbit is 0x0

5Bit for eofbit is 0x1

6Bit for failbit is 0x2

7Bit for badbit is 0x4

8Bit for hardfail is 0x80

9The value of good for cout is: 1

10The value of eof for cout is: 0

11The value of fail for cout is: 0

12The value of bad for cout is: 0

13

1// istream1.cpp

```
2// the istream class provides some useful functions
3// get          to extract a single character
4// peek        to look at next char without extracting
5// putback     to put character back into istream
6// read        to get a specified number of characters from stream
7// getline     to get up to a specified number of characters or
8//            to get up until a specified line terminator is encountered
9// seekg       to move the get pointer in the istream
10// tellg       to tell where the get pointer is in the istream
11
12#include <iostream.h>
13#include <stdio.h>
14#include <string.h>
15
16main()
17{
18    long int i,j,k,l,m,n,o;
19    char c;
20    char s[100];
21
22    i = cin.tellg();          // find out where the pointer is
23    s[0] = NULL;             // make sure s has nothing in it
24
25    cout << "Enter a character and press return please ";
26    cin >> c;                // read a character using >> operator
27    cout << "You entered " << c << endl;
28
29    j = cin.tellg();          // find out where the pointer is
30    s[0] = NULL;             // make sure s has nothing in it
31
32    cout << "Enter a character and press return please ";
33    c = cin.get();            // read a character using get operator
34    cout << "You entered " << c << endl;
35
36    // in this case we ask for a carriage return terminated string
37    // we use the cin operator >> which knows how to read into a
38    // character pointer
39    s[0] = NULL;
40    k = cin.tellg();
41    cout << "Enter a cr terminated string please ";
42    cin >> s;
43    cout << "You entered " << s << endl;
44
45    // in this case we ask for five characters,
46    // the system has been programmed to look for ten characters
47    // the system keeps reading until it sees ten characters
48    // even the carriage return does not terminate the string
49    s[0] = NULL;
50    l = cin.tellg();
51    cout << "Enter a 5 character, cr terminated string please ";
52    cin.read(s,10);
53    s[10] = NULL; // stop s from running away
54    cout << "You entered " << s << endl;
55
```

```

1      // in this case we ask for fifteen characters,
2      // the system has been programmed to look for ten characters
3      // the system keeps reading until it sees ten characters
4      // once it sees 10 characters it stops
5      s[0] = NULL;
6      m = cin.tellg();
7      cout << "Enter a 15 character, cr terminated string please ";
8      cin.read(s,10);
9      s[10] = NULL; // stop s from running away
10     cout << "You entered " << s << endl;
11
12     // in this case we are asking for a five character string that
13     // is to be terminated by an X
14     // the system has been programmed to look for up to 10 chars
15     // if the system sees ten characters, or an X, it stops reading
16     s[0] = NULL;
17     n = cin.tellg();
18     cout << "Enter a 5 character, X terminated string please ";
19     cin.getline(s,10,'X');
20     cout << "You entered " << s << endl;
21
22     s[0] = NULL;
23     o = cin.tellg();
24     cout << "Enter a 15 character, X terminated string please ";
25     cin.getline(s,10,'X');
26     cout << "You entered " << s << endl;
27
28     cout << endl << endl;
29     cout << "The input stream pointer was at " << i << endl;
30     cout << "The input stream pointer was at " << j << endl;
31     cout << "The input stream pointer was at " << k << endl;
32     cout << "The input stream pointer was at " << l << endl;
33     cout << "The input stream pointer was at " << m << endl;
34     cout << "The input stream pointer was at " << n << endl;
35     cout << "The input stream pointer was at " << o << endl;
36
37}

```

1Output From Running Program
2Enter a character and press return please You entered a
3Enter a character and press return please You entered e
4Enter a cr terminated string please You entered 234567890123
5Enter a 5 character, cr terminated string please You entered 4567890123
6Enter a 15 character, cr terminated string please You entered
7abcdeX
8fg
9Enter a 5 character, X terminated string please You entered jkX
10Enter a 15 character, X terminated string please You entered lmnopqrst
11
12
13The input stream pointer was at 0
14The input stream pointer was at 10
15The input stream pointer was at 17
16The input stream pointer was at 34
17The input stream pointer was at 48
18The input stream pointer was at 62
19The input stream pointer was at 67
20

1// istream2.cpp

```
2// the istream has a number of flags that control it
3// they can be read as a group
4// they can be queried individually to return a true/false answer
5
6#include <iostream.h>
7
8main()
9{
10     long int first_flags = 0;
11     int i;
12     char c;
13
14     first_flags = cin.flags();
15     cout << "The default value of the flags for cin is: ";
16     cout << hex << first_flags << endl;
17
18     cout << "Bit for skipws is  \t" << ios::skipws << endl;
19     cout << "Bit for left  is  \t" << ios::left  << endl;
20     cout << "Bit for right is  \t" << ios::right << endl;
21     cout << "Bit for internal is \t" << ios::internal << endl;
22     cout << "Bit for dec is   \t" << ios::dec << endl;
23     cout << "Bit for oct is   \t" << ios::oct << endl;
24     cout << "Bit for hex is   \t" << ios::hex << endl;
25     cout << "Bit for showbase is \t" << ios::showbase << endl;
26     cout << "Bit for showpoint is \t" << ios::showpoint << endl;
27     cout << "Bit for scientific is \t" << ios::scientific << endl;
28     cout << "Bit for fixed is   \t" << ios::fixed << endl;
29     cout << "Bit for unitbuf is   \t" << ios::unitbuf << endl;
30     cout << "Bit for stdio is   \t" << ios::stdio << endl;
31
32}
```

```

1Output From Running Program
2The default value of the flags for cin is: 1
3Bit for skipws is      1
4Bit for left  is      2
5Bit for right is      4
6Bit for internal is    8
7Bit for dec is    10
8Bit for oct is      20
9Bit for hex is      40
10Bit for showbase is  80
11Bit for showpoint is 100
12Bit for scientific is 800
13Bit for fixed is    1000
14Bit for unitbuf is  2000
15Bit for stdio is    4000
16

```


1// istream3.cpp

```
2// the istream has a number of flags that report its status
3// they can be read as a group
4// they can be queried individually to return a true/false answer
5
6#include <iostream.h>
7
8main()
9{
10     long int first_state = 0;
11     int i,j,k,l,m,n;
12
13     first_state = cin.rdstate();
14     cout << "The default value of the state for cin is: ";
15     cout << hex << first_state << endl;
16
17     cout << "Bit for goodbit is  \t" << ios::goodbit << endl;
18     cout << "Bit for eofbit is  \t" << ios::eofbit << endl;
19     cout << "Bit for failbit is  \t" << ios::failbit << endl;
20     cout << "Bit for badbit is  \t" << ios::badbit << endl;
21     cout << "Bit for hardfail is  \t" << ios::hardfail << endl;
22
23     j = cin.good();
24     cout << "The value of good for cin is: ";
25     cout << dec << j << endl;
26
27     k = cin.eof();
28     cout << "The value of eof for cin is: ";
29     cout << dec << k << endl;
30
31     l = cin.fail();
32     cout << "The value of fail for cin is: ";
33     cout << dec << l << endl;
34
35     m = cin.bad();
36     cout << "The value of bad for cin is: ";
37     cout << dec << m << endl;
38
39     // if the ostream gets into a bad state, you can attempt to
40     // clear it using
41     cin.clear();
42}
```

1Output From Running Program
2The default value of the state for cin is: 0
3Bit for goodbit is 0
4Bit for eofbit is 1
5Bit for failbit is 2
6Bit for badbit is 4
7Bit for hardfail is 80
8The value of good for cin is: 1
9The value of eof for cin is: 0
10The value of fail for cin is: 0
11The value of bad for cin is: 0
12

```

1// finfout.cpp
2
3// fstreams inherit from iostreams
4// ifstream inherits from istream
5// ofstream inherits from ostream
6
7// the streams have a collection of bits that describe their current state
8// the streams have a collection of functions to help manipulate them
9// the streams have a number of enumerated values that control how they
10// are opened.
11// subsequent programs, finfout1.cpp finfout2.cpp finfout3.cpp will explore
12// these bits, functions, and open mechanisms
13
14// this program simply opens a file and reads it
15
16#include <iostream.h>
17#include <fstream.h>
18#include <stdio.h>
19#include <stdlib.h>
20
21main()
22{
23    // open the data file for reading
24    ifstream in("finfout.dat");    // use default constructor
25    if ( in.good() )
26    {
27        cout << "File open succeeded\n";
28    }
29    else
30    {
31        cout << "File open failed\n";
32        exit(-1);
33    }
34
35    char c;
36    in >> c;
37    while ( in.eof() == 0 )
38    {
39        cout << c;
40        in >> c;
41    }
42
43    // now that we have generated an EOF
44    // look at the flags and try to clear the bad state
45    int i = in.rdstate();
46    cout << "\n the EOF but before the clear\n";
47    cout << "rdstate yielded " << i << endl;
48    i = in.good();
49    cout << "good yielded " << i << endl;
50    i = in.bad();
51    cout << "bad yielded " << i << endl;
52    i = in.eof();
53    cout << "eof yielded " << i << endl;
54    i = in.fail();
55    cout << "fail yielded " << i << endl;

```

```
1
2 // now try to clear the bad state
3 in.clear();
4 i = in.rdstate();
5 cout << "After the EOF and after the clear\n";
6 cout << "rdstate yielded " << i << endl;
7 i = in.good();
8 cout << "good yielded " << i << endl;
9 i = in.bad();
10 cout << "bad yielded " << i << endl;
11 i = in.eof();
12 cout << "eof yielded " << i << endl;
13 i = in.fail();
14 cout << "fail yielded " << i << endl;
15
16 // be nice and clean up after myself
17 in.close();
18}
19
```

```
1Output From Running Program
2File open succeeded
31234567890abcdefghih
4 the EOF but before the clear
5rdstate yielded 1
6good yielded 0
7bad yielded 0
8eof yielded 1
9fail yielded 0
10After the EOF and after the clear
11rdstate yielded 0
12good yielded 1
13bad yielded 0
14eof yielded 0
15fail yielded 0
16
```

1// finfout1.cpp

```
2// this program opens a file for reading
3// queries you for the name of the file you want to create and writes
4// the file opened for reading into the file opened for writing
5
6#include <iostream.h>
7#include <fstream.h>
8#include <stdio.h>
9#include <stdlib.h>
10
11main()
12{
13    // open the data file for reading
14    ifstream in("finfout.dat");    // use default constructor
15    if ( in.good() )
16    {
17        cout << "File open succeeded\n";
18    }
19    else
20    {
21        cout << "File open failed\n";
22        exit(-1);
23    }
24
25    // open the data file for writing
26    char out_name[100];    // should handle most file names
27    cout << "Enter file name to copy to \n";
28    cin >> out_name;
29    cout << "You entered " << out_name << endl;
30
31    ofstream out(out_name);    // automatically opened for writing
32    if ( out.good() )
33    {
34        cout << "Output File open succeeded\n";
35    }
36    else
37    {
38        cout << "Output File open failed\n";
39        exit(-2);
40    }
41
42    char c;
43    in >> c;
44    while ( in.eof() == 0 )
45    {
46        cout << c;    // write to the screen
47        out << c;    // write to the file
48        in >> c;
49    }
50    // be nice and clean up after myself
51    in.close();
52    out.close();
53}
```

1Output From Running Program
2File open succeeded
3Enter file name to copy to
4You entered copyto1
5Output File open succeeded
61234567890abcdefghih
7

1// finfout2.cpp

```
2// this program opens a file for reading and writing
3// it reads every other character from the file
4#include <iostream.h>
5#include <fstream.h>
6#include <stdio.h>
7#include <stdlib.h>
8
9// this program uses
10// seekg(number,position)
11// seekp(number,position)
12
13// the number may be positive or negative
14// positive => move forward number characters from position
15// negative => move backward number characters from position
16
17// position may be
18// ios::beg      beginning of file
19// ios::cur      current position in file
20// ios::end      ending of file
21
22
23// this program also uses
24// tellg()       report the current position of get pointer
25// tellp()       report the current position of put pointer
26main()
27{
28    char d;
29
30    // open the data file for reading and writing
31    // uses the two argument constructor
32    fstream inout("finfout2.dat", ios::in | ios::out | ios::nocreate );
33    if ( inout.good() )
34    {
35        cout << "File open succeeded\n";
36    }
37    else
38    {
39        cout << "File open failed\n";
40        exit(-1);
41    }
42
43    char c;
44
45    // find out where the end of the file is
46    inout.seekp(0,ios::end);          // move to end of file
47    int lastpos = inout.tellp();       // find out where end is
48    cout << "Last position in file is " << lastpos << endl;
49
50    int jtgetpos = 0;
51    inout.seekg(jtgetpos,ios::beg);    // position the input pointer
52    int curgetpos = inout.tellg();
53    cout << "Initial get position is " << curgetpos << endl;
54    inout >> c;
55    cout << "Read " << c << " from initial position \n";
```



```

1
2     while ( inout.eof() == 0 )
3     {
4         jtgetpos += 2;
5         inout.seekg(jtgetpos,ios::beg);    // position the input pointer
6         curgetpos = inout.tellg();
7         cout << "New get position is " << curgetpos << endl;
8         inout >> c;
9         cout << "Read " << c << " from new position \n";
10    }
11
12    // be nice and clean up after myself
13    inout.close();
14}
15
16Output From Running Program
17File open succeeded
18Last position in file is 14
19Initial get position is 0
20Read a from initial position
21New get position is 2
22Read c from new position
23New get position is 4
24Read e from new position
25New get position is 6
26Read g from new position
27New get position is 8
28Read i from new position
29New get position is 10
30Read i from new position
31

```

1// finfout3.cpp

```
2// this program opens a file for reading and writing
3// it reads every other character from the file and overwrites the
4// next character in the file
5// for example, an input file of
6// abcdefghij
7//           would be changed to
8// aacceeeggii
9
10#include <iostream.h>
11#include <fstream.h>
12#include <stdio.h>
13#include <stdlib.h>
14
15// this program uses
16// seekg(number,position)
17// seekp(number,position)
18
19// the number may be positive or negative
20// positive => move forward number characters from position
21// negative => move backward number characters from position
22
23// position may be
24// ios::beg      beginning of file
25// ios::cur      current position in file
26// ios::end      ending of file
27
28// this program also uses
29// tellg()       report the current position of get pointer
30// tellp()       report the current position of put pointer
31main()
32{
33    char d;
34
35    // open the data file for reading and writing
36    // uses the two argument constructor
37    fstream inout("finfout2.dat", ios::in | ios::out | ios::nocreate );
38    if ( inout.good() )
39    {
40        cout << "File open succeeded\n";
41    }
42    else
43    {
44        cout << "File open failed\n";
45        exit(-1);
46    }
47
48    char c;
49
50    // find out where the end of the file is
51    inout.seekp(0,ios::end);    // move to end of file
52    int lastpos = inout.tellp(); // find out where end is
53    cout << "Last position in file is " << lastpos << endl;
54
55    int jtgetpos = 0;
```

```

1      inout.seekg(jtgetpos,ios::beg); // position the input pointer
2      int curgetpos = inout.tellg();
3      cout << "Initial get position is " << curgetpos << endl;
4      inout >> c;
5      cout << "Read " << c << " from initial position \n";
6
7      while ( inout.eof() == 0 )
8      {
9          jtgetpos += 2;
10         inout.seekp(jtgetpos - 1, ios::beg);
11         inout.put(c);
12
13         inout.seekg(jtgetpos,ios::beg); // position the input pointer
14         curgetpos = inout.tellg();
15         cout << "New get position is " << curgetpos << endl;
16         inout >> c;
17         cout << "Read " << c << " from new position \n";
18     }
19
20     // be nice and clean up after myself
21     inout.close();
22 }
23
24 Output From Running Program
25 File open succeeded
26 Last position in file is 14
27 Initial get position is 0
28 Read a from initial position
29 New get position is 2
30 Read c from new position
31 New get position is 4
32 Read e from new position
33 New get position is 6
34 Read g from new position
35 New get position is 8
36 Read i from new position
37 New get position is 10
38 Read i from new position
39

```

1// ostristr.cpp

2// ostream and istream can be checked to be good or not
3// without using the function call cout.good() or cin.good()

```
4
5#include <iostream.h>
6
7main()
8{
9    char c;
10
11    cout << "Enter a letter and then press return\n";
12    cin >> c;
13    cout << "You entered " << c << endl;
14
15    if ( cout )
16    {
17        cout << "Cout is still in a good state\n";
18    }
19
20    if ( cin )
21    {
22        cout << "Cin is still in a good state \n";
23    }
24}
```

25
26
27Output From Running Program
28Enter a letter and then press return
29You entered a
30Cout is still in a good state
31Cin is still in a good state
32

```

1// predefs.cpp
2// C++ provides four predefined streams for you
3// cout          default output stream (stdout)
4// cin           default input stream (stdin)
5// cerr          default error stream (stderr)
6// clog
7
8#include <iostream.h>
9
10main()
11{
12    char c;
13    clog << "First Message sent to clog \n";
14    cout << "Message sent to cout \n";
15    clog << "Second Message sent to clog \n";
16    cerr << "Message sent to cerr \n";
17    clog << "Third Message sent to clog \n";
18
19    cout << "Enter a letter and press return \n";
20    cin >> c;
21    cout << "You entered " << c << endl;
22
23    clog << "Fourth Message sent to clog \n";
24}
25
26
27Output From Running Program
28Message sent to cout
29Enter a letter and press return
30You entered b
31

```

1// filebit1.cpp

```
2// the fstreams have a number of flags that control it
3// they can be read as a group
4// they can be queried individually to return a true/false answer
5
6#include <iostream.h>
7#include <fstream.h>
8
9main()
10{
11    long int first_flags = 0;
12    int i;
13    char c;
14
15    ifstream in("filebits.in"); // use default constructor
16    ofstream out("filebits.out"); // use default constructor
17
18    first_flags = in.flags();
19    cout << "The default value of the flags for in is: ";
20    cout << hex << first_flags << endl << endl;
21
22    first_flags = out.flags();
23    cout << "The default value of the flags for out is: ";
24    cout << hex << first_flags << endl << endl;
25
26    cout << "Bit for skipws is  \t" << ios::skipws << endl;
27    cout << "Bit for left  is  \t" << ios::left << endl;
28    cout << "Bit for right is  \t" << ios::right << endl;
29    cout << "Bit for internal is \t" << ios::internal << endl;
30    cout << "Bit for dec is   \t" << ios::dec << endl;
31    cout << "Bit for oct is   \t" << ios::oct << endl;
32    cout << "Bit for hex is   \t" << ios::hex << endl;
33    cout << "Bit for showbase is \t" << ios::showbase << endl;
34    cout << "Bit for showpoint is \t" << ios::showpoint << endl;
35    cout << "Bit for scientific is \t" << ios::scientific << endl;
36    cout << "Bit for fixed is   \t" << ios::fixed << endl;
37    cout << "Bit for unitbuf is  \t" << ios::unitbuf << endl;
38    cout << "Bit for stdio is   \t" << ios::stdio << endl;
39
40}
```

```

1Output From Running Program
2The default value of the flags for in is: 1
3
4The default value of the flags for out is: 1
5
6Bit for skipws is      1
7Bit for left  is      2
8Bit for right is      4
9Bit for internal is    8
10Bit for dec is      10
11Bit for oct is      20
12Bit for hex is      40
13Bit for showbase is  80
14Bit for showpoint is 100
15Bit for scientific is 800
16Bit for fixed is     1000
17Bit for unitbuf is   2000
18Bit for stdio is     4000
19

```

```

1// filebit2.cpp
2#include <iostream.h>
3#include <fstream.h>
4main()
5{
6    long int first_state = 0;
7    int i,j,k,l,m,n;
8
9    ifstream in("filebit2.in");
10   first_state = in.rdstate();
11   cout << "The default value of the state for in is: ";
12   cout << hex << first_state << endl;
13
14   cout << "Bit for goodbit is  \t" << ios::goodbit << endl;
15   cout << "Bit for eofbit is  \t" << ios::eofbit << endl;
16   cout << "Bit for failbit is  \t" << ios::failbit << endl;
17   cout << "Bit for badbit is  \t" << ios::badbit << endl;
18   cout << "Bit for hardfail is  \t" << ios::hardfail << endl;
19
20   j = in.good();
21   cout << "The value of good for in is: ";
22   cout << dec << j << endl;
23
24   k = in.eof();
25   cout << "The value of eof for in is: ";
26   cout << dec << k << endl;
27
28   l = in.fail();
29   cout << "The value of fail for in is: ";
30   cout << dec << l << endl;
31
32   m = in.bad();
33   cout << "The value of bad for in is: ";
34   cout << dec << m << endl;
35
36   // if the ostream gets into a bad state, you can attempt to
37   // clear it using
38   in.clear();
39
40   ofstream out("filebit2.out");
41   first_state = out.rdstate();
42   cout << "The default value of the state for out is: ";
43   cout << hex << first_state << endl;
44
45   cout << "Bit for goodbit is  \t" << ios::goodbit << endl;
46   cout << "Bit for eofbit is  \t" << ios::eofbit << endl;
47   cout << "Bit for failbit is  \t" << ios::failbit << endl;
48   cout << "Bit for badbit is  \t" << ios::badbit << endl;
49   cout << "Bit for hardfail is  \t" << ios::hardfail << endl;
50
51   j = out.good();
52   cout << "The value of good for out is: ";
53   cout << dec << j << endl;
54
55   k = out.eof();

```



```

1      cout << "The value of eof for out is: ";
2      cout << dec << k << endl;
3
4      l = out.fail();
5      cout << "The value of fail for out is: ";
6      cout << dec << l << endl;
7
8      m = out.bad();
9      cout << "The value of bad for out is: ";
10     cout << dec << m << endl;
11
12     // if the ostream gets into a bad state, you can attempt to
13     // clear it using
14     out.clear();
15
16}
17
18Output From Running Program
19The default value of the state for in is: 0
20Bit for goodbit is      0
21Bit for eofbit  is      1
22Bit for failbit is      2
23Bit for badbit  is      4
24Bit for hardfail is     80
25The value of good for in is: 1
26The value of eof for in is: 0
27The value of fail for in is: 0
28The value of bad for in is: 0
29The default value of the state for out is: 0
30Bit for goodbit is      0
31Bit for eofbit  is      1
32Bit for failbit is      2
33Bit for badbit  is      4
34Bit for hardfail is     80
35The value of good for out is: 1
36The value of eof for out is: 0
37The value of fail for out is: 0
38The value of bad for out is: 0
39

```

1// fileop1.cpp

```
2// C++ allows you to work with files
3// C++ can work with C files just the way you already know them
4// I recommend staying with the C file routines because they are
5// widely and correctly implemented
6
7#include <stdio.h>
8#include <iostream.h>
9#include <fstream.h> // get access to the file routines
10
11// ifstream inherits from istream
12// ofstream inherits from ostream
13
14// There are several bits that control how a file is opened
15// they are enumerated in iostream.h
16
17//      in          open for reading
18//      out         open for writing
19
20//      ate         seek to eof on original open
21
22//      app         append, seek to eof on open
23
24//      trunc       delete file if it already exists
25//      nocreate     open fails if file doesn't already exist
26//      noreplace    open fails if file already does exist
27
28//      binary      open file in binary mode, not a text file
29
30// there are several functions for querying the status of a file
31// rdstate()
32// eof()
33// fail()
34// bad()
35// good()
36
37// if these calls look familiar, they are, remember that ifstream and ofstream
38// inherit from istream and ostream
39main()
40{
41    char c;
42
43    ofstream out("fileopen.dat"); // open for output, use default constructor
44    out << "This message came from fileopen.cpp \n";
45    out.close(); // close the file
46
47    ifstream in("fileopen.dat"); // open for input, use default constructor
48    in >> c; // get character from file
49    while ( in.eof() == 0 )
50    {
51        cout << c; // print that character on screen
52        in >> c; // get the next character
53    }
54    in.close();
55    cout << endl << endl;
```

```

1
2 // now look at the difference that skipws will have when we use
3 // the exact same code to read from the file
4 ifstream wsin("fileopen.dat"); // open for input, use default constructor
5 wsin.unsetf(ios::skipws); // DO NOT SKIP WS ON INPUT
6
7 wsin >> c; // get character from file
8 while ( wsin.eof() == 0 )
9 {
10     cout << c; // print that character on screen
11     wsin >> c; // get the next character
12 }
13 // now that we have encountered an EOF, let's see what that did to
14 // the other calls available
15 int after = wsin.rdstate();
16 int eof_stat = wsin.eof();
17 int fail_stat = wsin.fail();
18 int bad_stat = wsin.bad();
19 int good_stat = wsin.good();
20
21 cout << "\n\nBefore clear flags for wsin are " << after << endl;
22 cout << "eof stat for wsin is " << eof_stat << endl;
23 cout << "fail stat for wsin is " << fail_stat << endl;
24 cout << "bad stat for wsin is " << bad_stat << endl;
25 cout << "good stat for wsin is " << good_stat << endl;
26
27 // now try to clear the stream using clear and then
28 // look at the bits again
29 wsin.clear();
30 after = wsin.rdstate();
31 eof_stat = wsin.eof();
32 fail_stat = wsin.fail();
33 bad_stat = wsin.bad();
34 good_stat = wsin.good();
35
36 cout << "\n\nAfter clear flags for wsin are " << after << endl;
37 cout << "eof stat for wsin is " << eof_stat << endl;
38 cout << "fail stat for wsin is " << fail_stat << endl;
39 cout << "bad stat for wsin is " << bad_stat << endl;
40 cout << "good stat for wsin is " << good_stat << endl;
41
42 wsin.close();
43 cout << endl << endl;
44}

```

```
1Output From Running Program
2Thismessagecamefromfileopen.cpp
3
4This message came from fileopen.cpp
5
6
7Before clear flags for wsin are 3
8eof stat for wsin is 1
9fail stat for wsin is 2
10bad stat for wsin is 0
11good stat for wsin is 0
12
13
14After clear flags for wsin are 0
15eof stat for wsin is 0
16fail stat for wsin is 0
17bad stat for wsin is 0
18good stat for wsin is 1
19
20
21
```

1// fileop2.cpp

```
2// this program illustrates the different ways files can be opened
3
4#include <stdio.h>
5#include <iostream.h>
6#include <fstream.h>    // get access to the file routines
7
8// There are several bits that control how a file is opened
9// they are enumerated in iostream.h
10
11//      in          open for reading
12//      out         open for writing
13
14//      ate         seek to eof on original open
15
16//      app         append, seek to eof on open
17
18//      trunc       delete file if it already exists
19//      nocreate     open fails if file doesn't already exist
20//      noreplace    open fails if file already does exist
21
22//      binary       open file in binary mode, not a text file
23
24main()
25{
26    int rdstat,eof_stat,fail_stat,bad_stat,good_stat;
27
28    // open for reading
29    ifstream in1("fileop2.in", ios::in );
30
31    rdstat  = in1.rdstate();
32    eof_stat = in1.eof();
33    fail_stat = in1.fail();
34    bad_stat = in1.bad();
35    good_stat = in1.good();
36
37    cout << "Status bits for in1 are \n";
38    cout << "rdstat for is " << rdstat << endl;
39    cout << "eof stat  is " << eof_stat << endl;
40    cout << "fail stat  is " << fail_stat << endl;
41    cout << "bad stat   is " << bad_stat << endl;
42    cout << "good stat  is " << good_stat << endl;
43
44    in1.close();
45
46    // open for reading, and writing
47    ifstream inout1("fileop2.in", ios::in | ios::out );
48
49    rdstat  = inout1.rdstate();
50    eof_stat = inout1.eof();
51    fail_stat = inout1.fail();
52    bad_stat = inout1.bad();
53    good_stat = inout1.good();
54
55    cout << "Status bits for inout1 are \n";
```

```

1      cout << "rdstat for is " << rdstat << endl;
2      cout << "eof stat  is " << eof_stat << endl;
3      cout << "fail stat  is " << fail_stat << endl;
4      cout << "bad stat  is " << bad_stat << endl;
5      cout << "good stat is " << good_stat << endl;
6
7      inout1.close();
8
9      // open for writing
10     ifstream out1("fileop2.out", ios::out );
11
12     rdstat  = out1.rdstate();
13     eof_stat = out1.eof();
14     fail_stat = out1.fail();
15     bad_stat = out1.bad();
16     good_stat = out1.good();
17
18     cout << "Status bits for out1 are \n";
19     cout << "rdstat for is " << rdstat << endl;
20     cout << "eof stat  is " << eof_stat << endl;
21     cout << "fail stat  is " << fail_stat << endl;
22     cout << "bad stat  is " << bad_stat << endl;
23     cout << "good stat is " << good_stat << endl;
24
25     out1.close();
26 }
27

```

1Output From Running Program
2Status bits for in1 are
3rdstat for is 0
4eof stat is 0
5fail stat is 0
6bad stat is 0
7good stat is 1
8Status bits for inout1 are
9rdstat for is 0
10eof stat is 0
11fail stat is 0
12bad stat is 0
13good stat is 1
14Status bits for out1 are
15rdstat for is 0
16eof stat is 0
17fail stat is 0
18bad stat is 0
19good stat is 1

1// fileop3.cpp

```
2// this program illustrates more different ways files can be opened
3
4#include <stdio.h>
5#include <iostream.h>
6#include <fstream.h> // get access to the file routines
7
8// There are several bits that control how a file is opened
9// they are enumerated in iostream.h
10
11//      in          open for reading
12//      out         open for writing
13
14//      ate         seek to eof on original open
15
16//      app         append, seek to eof on open
17
18//      trunc       delete file if it already exists
19//      nocreate     open fails if file doesn't already exist
20//      noreplace    open fails if file already does exist
21
22//      binary       open file in binary mode, not a text file
23
24main()
25{
26    int rdstat,eof_stat,fail_stat,bad_stat,good_stat;
27
28    // open for reading, open fails if file doesn't exist
29    ifstream in1("fileop3.in1", ios::in | ios::nocreate );
30
31    rdstat  = in1.rdstate();
32    eof_stat = in1.eof();
33    fail_stat = in1.fail();
34    bad_stat = in1.bad();
35    good_stat = in1.good();
36
37    cout << "Status bits for in1 are \n";
38    cout << "rdstat for is " << rdstat << endl;
39    cout << "eof stat  is " << eof_stat << endl;
40    cout << "fail stat  is " << fail_stat << endl;
41    cout << "bad stat   is " << bad_stat << endl;
42    cout << "good stat  is " << good_stat << endl;
43
44    in1.close();
45
46    // open for reading, fails if file already exists
47    // DOES THIS ONE MAKE SENSE?
48    ifstream in2("fileop3.in2", ios::in | ios::noreplace );
49
50    rdstat  = in2.rdstate();
51    eof_stat = in2.eof();
52    fail_stat = in2.fail();
53    bad_stat = in2.bad();
54    good_stat = in2.good();
55
```



```

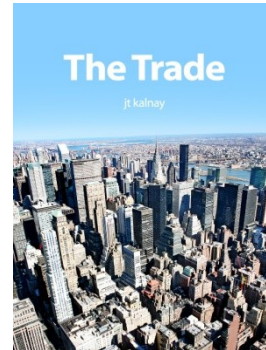
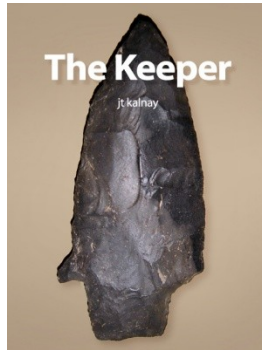
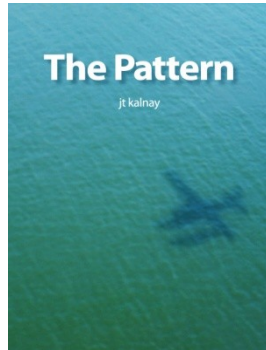
1      cout << "Status bits for in2 are \n";
2      cout << "rdstat for is " << rdstat << endl;
3      cout << "eof stat is " << eof_stat << endl;
4      cout << "fail stat is " << fail_stat << endl;
5      cout << "bad stat is " << bad_stat << endl;
6      cout << "good stat is " << good_stat << endl;
7
8      in2.close();
9
10     // open for reading, delete if file already exists
11     // DOES THIS ONE MAKE SENSE?
12     ifstream in3("fileop2.in3", ios::in | ios::trunc );
13
14     rdstat  = in3.rdstate();
15     eof_stat = in3.eof();
16     fail_stat = in3.fail();
17     bad_stat = in3.bad();
18     good_stat = in3.good();
19
20     cout << "Status bits for in3 are \n";
21     cout << "rdstat for is " << rdstat << endl;
22     cout << "eof stat is " << eof_stat << endl;
23     cout << "fail stat is " << fail_stat << endl;
24     cout << "bad stat is " << bad_stat << endl;
25     cout << "good stat is " << good_stat << endl;
26
27     in3.close();
28
29}

```

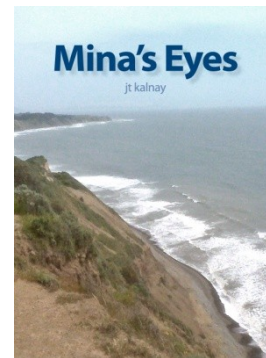
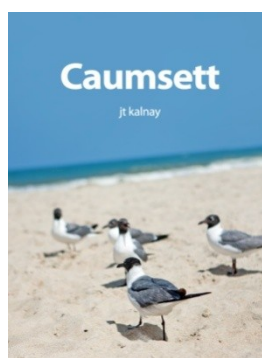
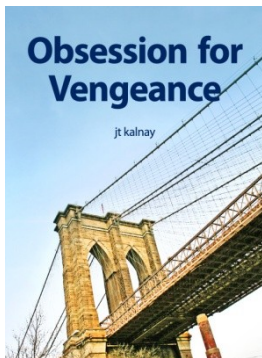
1Output From Running Program
2Status bits for in1 are
3rdstat for is 4
4eof stat is 0
5fail stat is 4
6bad stat is 4
7good stat is 0
8Status bits for in2 are
9rdstat for is 4
10eof stat is 0
11fail stat is 4
12bad stat is 4
13good stat is 0
14Status bits for in3 are
15rdstat for is 4
16eof stat is 0
17fail stat is 4
18bad stat is 4
19good stat is 0

- 1 After JT Decided He Couldn't Write One More Program....
2 He Started Writing Novels,
3 Please Consider Reading The Pattern (it's about a programming error)
4 Or Consider Sampling Others of JT Kalnay's Novels

5

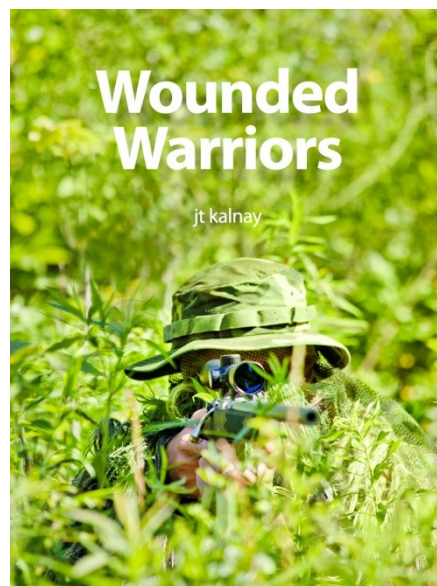


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1 Reviews for JT's Programming Technothriller The Pattern

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3 The first of JT Kalnay's works I've read, this early effort compares nicely with
4Ryan's "Adolescence of P-1" or Grisham's "The Firm" but wisely navigates around
5Powers' "Galatea 2.2" territory. You get a good sense this writer has "been there"
6but there is more to "The Pattern" than just an insider's view of an industry and
7culture that is pretty much a black box to those that haven't. This one gets a 4 out of
85 simply for not quite cracking the level of the big boys: Clancy, Ludlum, Cussler et
9al. Will be interested to see how this author develops in this genre.

10

11 I was surprised to enjoy this book so much as it comes from a not so well known
12author. Fantastic fiction.

13

14 I was thinking about the HAL 9000 malfunction in 2001 A Space Odyssey while
15reading The Pattern. Decades ago, I wondered if people would risk their lives on
16software. Now we have fly-by-wire controls in our airplanes and we depend on
17software in our hospital equipment as well as our cars. Software glitches can now
18kill. It's a really scary thought and I really enjoyed the thrilling journey the author
19takes us on in this techno-thriller treat. In the best spirit of science fiction it gives us
20pause to consider the dependency we freely give to our technology. In addition, as
21this story unfolds our humanity is laid bare in the face of technological realities that
22are seldom realized by most of us.

1 Please Enjoy This Sample From The Pattern
2 June 19, 1994
3 Chantilly Virginia
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5 Assembled From News Wire Reports
6
7 A chartered executive Lear Jet inbound from Mexico City crashed today in heavy
8 fog during final approach to Dulles National Airport in Washington D.C. Ten
9 passengers and two crew members were killed instantly. There were no Americans
10 on the flight and there were no survivors. Although the airplane had the latest
11 electronics, it had aborted one landing due to the fog and was in the process of lining
12 up for a second attempt when the accident occurred. The black box flight recorder
13 has been recovered from the wreckage and the bodies have been identified. The last
14 transmission from the cockpit was, "There seems to be something wrong with the
15 electronics. Going around." The plane disappeared from radar less than ten seconds
16 later.
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19 June 20, 1994
20 San Francisco, California
21
22 Thin clouds drifted high above the city by the Bay. Craig and Stacey sat behind
23 the APSoft building on the large cedar deck. A gentle breeze caressed Stacey's long,
24 summer golden hair. Craig was having a very hard time concentrating on the report
25 in his hands.
26 "Do you want to hear something weird?" Stacey asked.
27 "I don't know. Do I?" Craig answered.
28 "Yes. You do," Stacey said.
29 "Okay. Let's have it," Craig said.
30 "We're three for three this year," Stacey said.
31 "I don't get it," Craig said.
32 "On airplane crashes. We're three for three."
33 "I still don't get it," Craig said.
34 "Listen. First you know that guy in Turkey where the Blackhawks got shot down.
35 Second, we both know Rakesh who's been in Hong Kong where the plane that
36 crashed in Nagoya originated. Third, my friend in Mexico works for that company
37 that chartered that plane that crashed in Virginia the other day. We're three for
38 three."
39 "Better call the National Enquirer," Craig said.
40 "Jerk," Stacey said.
41 "We know somebody at almost every airline or aircraft manufacturer in the world
42 Stacey. It'd be a miracle if we didn't know someone somehow related to every
43 crash," Craig said.
44 "You're still a jerk," Stacey said.
45 "Yeah I know. It's part of my charm," he replied.
46 Stacey made a face at him and rolled her eyes.
47 "Please," she said.

1 "But you know what? You've piqued my curiosity. I'm going to do some research
2 and see how many wrecks there have been in the last year. It does seem like there's
3 been an unusual amount doesn't it?" Craig asked.

4 "Nice try," Stacey said.

5 "No. I'm totally serious. Now that you've pointed it out, I really am curious."

6 "Um huh," she said dismissively.

7 "Ready to throw it some more," Stacey asked, dangling Craig's birthday Frisbee
8 on the end of a long slender finger.

9 "Not right now," Craig said. I better get started on that research.

10

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<http://jtkalnaynovels.wordpress.com/>

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www.jtkalnay.com



JT Kalnay is an attorney and an author. He has been an athlete, a soldier, a professor, a programmer, an Ironman, and mountain climber. JT now divides his time between being an attorney, being an author, and helping his wife chase after seven nieces and nephews.

JT was born and raised in Belleville, Ontario, Canada. Growing up literally steps from the Bay of Quinte, water, ice, fishing, swimming, boating, and drowning were very early influences and appear frequently in his work.

Educated at the Royal Military College, the University of Ottawa, the University of Dayton, and Case Western Reserve University, JT has spent countless hours studying a wide range of subjects including math, English, computer science, physics, and law. Many of his stories are set on college campuses. JT (along with MC and KR) is one of the founding members of the Stone Frigate Military Academy English Society.

JT is a certified rock climbing guide and can often be found atop crags in West Virginia, California, Texas, New Mexico, Nevada, Kentucky, Mexico, and Italy. Rock climbing appears frequently in his writing.

JT has witnessed firsthand many traumatic events including the World Trade Center Bombing, the Long Island Railroad Shooting, a bear attack, a plane crash, and numerous fatalities, in the mountains and elsewhere.

Disasters, loss, and confronting personal fear are common themes in his writing.

www.jtkalnay.com