C++ As a Better C

C++ Object Oriented Programming

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- Comments
- User-defined type names
- Function prototypes in C++
- Function signatures
- Better I/O library
- Default function arguments
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- Rules:
  - Use // syntax for **single-line** comments
  - Use /*…*/ syntax for **multi-line** comments

User-defined Type Names

- struct, enum, union tags are type names
  - struct:

    ```
    struct Stack {
       …
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union Value {
    int iValue;
    double dValue;
};
```

    - C: union Value field;
    - C++: Value field;

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  - enum:

    ```
    enum Color {RED, GREEN, BLUE};
    ```

    - C: enum Color bgColor;
    - C++: Color bgColor;

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Function Prototypes in C++

- Function prototypes are REQUIRED
  - Otherwise you must define the function before you use it, i.e. in Pascal-style
  - In K&R C (before ANSI C), a function *foo* used without suitable prototype has default prototype, arguments are passed with default promotion rules (i.e. 4bytes / 8bytes rule)

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  - ✶ int printf(const char *format, **…**);

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C++ still keep it for compatibility

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```

or

```
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in C++ file

Better Input/Output

- **Type-aware** I/O processing, mixed data types

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- Seamlessly Extensible

Default Function Arguments

- Function arguments can be given default (optional) values.

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void printName(char *first, char *last, bool inverted);
void main() {
   char firstName[50]="Joe", lastName[50]="Smith";

   printName(firstName, lastName, false);
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Good for avoiding seldom-used parameters

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- Corrections

```
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```

Output: 25

- **Problems** with preprocessor macros
  - The preprocessor knows nothing about C syntax or semantics
  - Cannot debug into a macro function

  i.e. a macro is invisible to the compiler / debugger

- The same macro **fails** on the following

```
int x=5, y=6;
cout <<  ((x+y)*(x+y));
```

- Corrections

```
#define square(x) ((x)*(x))
```

Macros (cont’d)

- Not every macro problem can be solved by parenthesizing

```
#define inverse(x) (1/(x))
double x=5;
cout << "x=" << inverse(x) << endl;
int y=5;
cout << "y=" << inverse(y) << endl;
```

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```

```
Output:
x=.2
y=0
```

Macros (cont'd)

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x=.2
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- Corrections:

```
#define inverse(x) (1.0/(x))
```

- Arguments of a macro could be evaluated more than once

```
#define square(x) ((x)*(x))
…
int x=5;
cout << "square of 5 is " << square(x++) << ", x=" << x;
```

Macros (cont’d)

- Not every macro problem can be solved by parenthesizing

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int x=5;
cout << "square of 5 is " << square(x++) << ", x=" << x;
```

```
Output:
square of 5 is 30, x=7
```

Macros (cont’d)

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double x=5;
cout << "x=" << inverse(x) << endl;
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x=.2
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```
Output:
square of 5 is 30, x=7
```

- There are various problems with macros, all require prudent inspections.

```
#define IPTR int *
IPTR x, y;
```

Inline Functions

- C++ has inline functions, which provide the same functionality as macros without the above drawbacks

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        inline int square(int x); // function prototype, not a macro
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Inline Functions

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inline int square(int x); // function prototype, not a macro
void main() {
    int x=5, y=6;
    cout << square(x+y);
}
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```

```
Output: 121
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```

Output: 121

```
inline double inverse(double x);





inline double inverse(double x) { return 1 / x;}
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```

```
Output: 121
```

```
inline double inverse(double x);
void main() {
   int x=5;
   cout << inverse(x);
}
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```

```
Output: .2
```

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inline double inverse(double x);
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    cout << inverse(x);
}
inline double inverse(double x) { return 1 / x;}
```

Output: .2

- The compiler can only inline **known** and **simple** functions (compiler-dependent) and will IGNORE all other inline requests.

Declare Variables On-the-fly

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- Ex.

```
void main() {
   int array[5] = {0, 1, 2, 3, 4};
   cout << array[0] << endl;
   …
   int sum = 0;
   for (int i=0; i<5; i++)
      sum += array[i];
   cout << sum;
}
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    int sum = 0;                                    ⎫
    for (int i=0; i<5; i++)      ⎫ the scope        ⎬ the scope
        sum += array[i];         ⎭  of  i           ⎪  of  sum
    cout << sum;                                    ⎭
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    …
    int sum = 0;                          ⎫
    for (int i=0; i<5; i++)     ⎫ the scope ⎬ the scope
        sum += array[i];        ⎭ of  i     ⎪ of  sum
    cout << sum;                          ⎭
}
```

```
if (int items=…) {
    cout << items;
}
// cout << items;
```

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        sum += array[i];
    cout << sum;
}
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the scope of i

the scope of sum

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if (int items=…) {
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```

- Why should you do this?

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- Why should you do this? better readability

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```
if (int items=…) {
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}
// cout << items;
```

- Why should you do this? better readability
  encourages single-usage variables
  - Most commonly used for temporary loop variables

Declare Variables On-the-fly (cont’d)

- Cannot branch over ‘a variable definition with initialization’

Declare Variables On-the-fly (cont’d)

- Cannot branch over ‘a variable definition with initialization’

error

```
void main()
{
    int x;
    x = 1;
    goto test;
    int y=5;
test:
    x = 2;
    y = 10;
}
```

Declare Variables On-the-fly (cont’d)

- Cannot branch over ‘a variable definition with initialization’

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}
```

error

```
void main()
{
   int x=1;
   switch (x) {
   case 1:
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      break;
   case 2:
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      …
   }
}
```

Declare Variables On-the-fly (cont’d)

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}
```

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{
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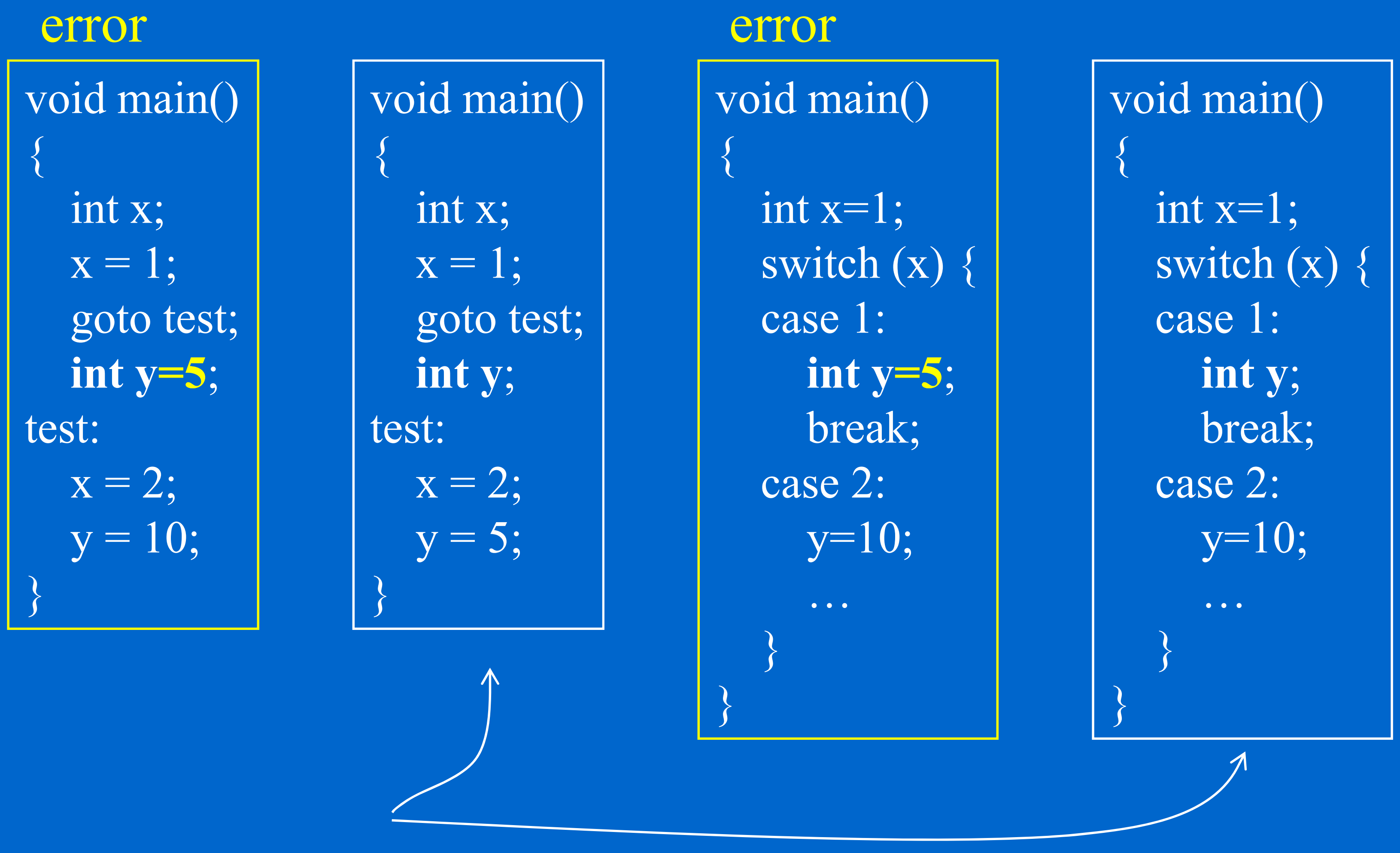

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      break;
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      …
   }
}
```

Compilation OK, but better not do this, use suitable block structure instead

#define vs. const

- Defines should be replaced by constant variables in C++

```
#define kMaxSize 1000
const int kMaxSize = 1000;          // much better
```

#define vs. const

- **Defines should be replaced by constant variables in C++**

  ~~#define kMaxSize 1000~~ // not anymore

  const int kMaxSize = 1000; // much better

  int array[kMaxSize];

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- **A constant variable is a real variable, therefore, has a type that compiler can check upon, and is visible to the debugger.**

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```
static bool isStartWithH(const char *inputString) {
    char firstLetter = inputString[0];
    firstLetter = toupper(firstLetter);
    return firstLetter == 'H';
}
```

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  ~~#define kMaxSize 1000~~ // not anymore

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Compiler guarantees that the following won't happen

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    char firstLetter = inputString[0];
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}
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Usually used with pointer or reference parameters

Don’t bother trying this!

```
int size;
cin >> size;
const int kMax = size;
int array[kMax];
```

Compiler guarantees that the following won’t happen

```
static bool isStartWithH(const char *inputString) {
    inputString[0] = toupper(inputString[0]);
    return inputString[0] == 'H';
}
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const int kMaxSize = 1000; // much better

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More on Constant Variables

- ‘const’ modifies the type specifier differently according to its position

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void main()
{
    char string1[kMaxSize] = "Hello world";
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}
```

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```
void main()
{
    char string1[kMaxSize] = "Hello world";
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    string1[0] = 'T';                        // legal









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More on Constant Variables

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void main()
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    char string1[kMaxSize] = "Hello world";
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    const char *ptrString1 = string1;









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}
```

chars being pointed at are constants, but char* is not

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or char **const** *ptrString1;

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   ptrString2[0] = 'T';                       // legal
   ptrString2++;                              // illegal
   ptrString2 = string2;                      // illegal


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   ptrString2++;                        // illegal
   ptrString2 = string2;                // illegal
   char *const ptrString3;              // illegal


}
```

or char **const** *ptrString1;

chars being pointed at are constants, but char* is not

char* is a constant, chars being pointed at are not

More on Constant Variables

✧ ‘const’ modifies the type specifier differently according to its position

```
void main()
{
    char string1[kMaxSize] = "Hello world";
    char string2[kMaxSize] = "Good bye";
    string1[0] = 'T';                        // legal

    const char *ptrString1 = string1;
    ptrString1[0] = 'T';    // *ptrString1='T'; illegal
    ptrString1++;                            // legal

    char *const ptrString2 = string1;
    ptrString2[0] = 'T';                     // legal
    ptrString2++;                            // illegal
    ptrString2 = string2;                    // illegal
    char *const ptrString3;                  // illegal

    const char *const ptrString4 = string1;
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    ptrString1[0] = 'T';    // *ptrString1='T'; illegal
    ptrString1++;                              // legal

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    ptrString2++;                              // illegal
    ptrString2 = string2;                      // illegal
    char *const ptrString3;                    // illegal

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int func() {
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file1.c

```
static int x1;
int x2;
static int func1(int x) { … }
int func2(int x) { … }
```

file2.c

```
int func() {
    extern int x1; int func1(int);
    int func2(int);
    func1(x1);  // both undefined
    func2(x2);  // OK
}
```

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- In C++, these semantics remain the same.

New Ways to Handle Memory

- C++ has better ways to allocate/deallocate memory

C		
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- Ex.

```
int *x, *y;
int *array;
x = new int;
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C	**malloc**	**free**
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```
int *x, *y;
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```

initialization: single-value variables (not for arrays) and objects

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```
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delete x;
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int *ptr=0; // NULL
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if (ptr!=0) free(ptr);          // freeing NULL is fatal in C/C++
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    static int newFailed(size_t size) {







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static int newFailed(size_t size) {
    if (gSparePtr!=0) {




    }
    return 0; // stop retrying
}
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- Ex.

```
static int newFailed(size_t size) {
    if (gSparePtr!=0) {
        delete [] gSparePtr; // free some spare space
        gSparePtr = 0;
        cout << "[newFailed " << size << "]";
        return 1; // request the new operator to retry
    }
    return 0; // stop retrying
}
```

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    gSparePtr = new int[20000000]; // 80MB
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    for (i=0; i<20; i++) {
        cout << i << " ";
        ptr[i] = new int[5000000]; // 20MB
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2 2B2F0020
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    for (i=0; i<20; i++) {
        cout << i << " ";
        ptr[i] = new int[5000000]; // 20MB
        cout << ptr[i] << endl;
    }
```

```
0 28CB0020
1 29FD0020
2 2B2F0020
3 2C610020
4 2D930020
5 2EC50020
6 2FF70020
7 31290020
8 325B0020
9 338D0020
10 [newFailed 20000000]
    34BF0020
11 35F10020
12 37230020
13 38550020
14 00000000
15 00000000
16 00000000
17 00000000
18 00000000
19 00000000
```

Handling Memory Allocation Errors

- Installing and resetting the new handler VC6.0

```
#include <new.h>
int *gSparePtr = 0;
static int newFailed(size_t size);
void main() {
    _PNH old_handler = _set_new_handler(newFailed);
    gSparePtr = new int[20000000]; // 80MB
    int *spoiled = new int[150000000]; // 600MB
    int *ptr[20], i;

    for (i=0; i<20; i++) {
        cout << i << " ";
        ptr[i] = new int[5000000]; // 20MB
        cout << ptr[i] << endl;
    }

    _set_new_handler(old_handler);
}
```

```
0 28CB0020
1 29FD0020
2 2B2F0020
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7 31290020
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10 [newFailed 20000000]
   34BF0020
11 35F10020
12 37230020
13 38550020
14 00000000
15 00000000
16 00000000
17 00000000
18 00000000
19 00000000
```

restore the original new handler
can also call _set_new_handler(0) to remove

Handling Memory Allocation Errors

- ANSI C++ version of set_new_handler

```
#include <new>
using namespace std;
…
static void newHandler();
…
void main() {
   new_handler old_handler=set_new_handler(newHandler);
   …
   set_new_handler(old_handler);
}
…
static void newHandler() {
…
}
```

In VC6.0 this does not work, because set_new_handler() is implemented as a stub function only.

References

- C simulates “call by reference” through pointers

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void func(int *ptrData) {
    *ptrData = 10;
}
```

```
void main() {
    int data;
    …
    func(&data);
    …
}
```

References

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    *ptrData = 10;
}
```

```
void main() {
    int data;
    . . .
    func(&data);
    . . .
}
```

- C++ has true references

```
void func(int &param) {
    param = 10;
}
```

```
void main() {
    int data;
    . . .
    func(data);
    . . .
}
```

References

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no pointer dereference required

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no address-of operator required

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no pointer dereference required

```
void main() {
    int data;
    …
    func(data);
    …
}
```

no address-of operator required

- Some C++ programmers might do the following for saving time and memory

```
void Foo(const CBigData &data) {
…
}
```

References (cont'd)

- There are no promotions or type conversions with references

References (cont’d)

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```
void func(double &data) {
    data = 10;
}
```

```
void main() {
    int data;
    . . .
    func(data);
    . . .
}
```

References (cont’d)

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```
void func(double &data) {
    data = 10;
}
```

```
void main() {
    int data;
    . . .
    func(data);
    . . .
}
```

```
error C2664: 'func' : cannot convert parameter 1  from 'int' to 'double &'
```

References (cont’d)

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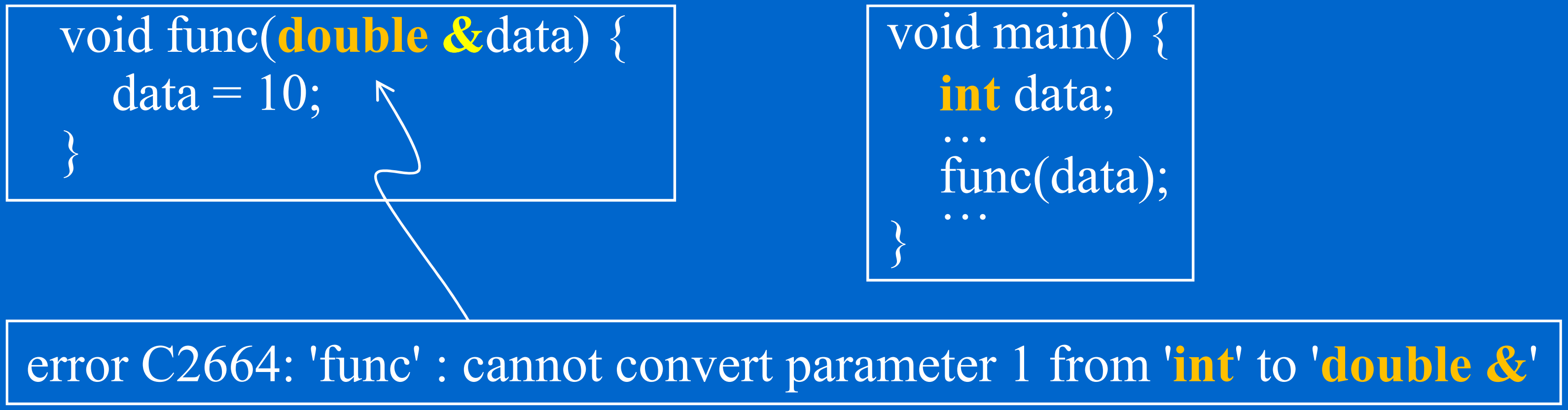

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    . . .
}
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error C2664: 'func' : cannot convert parameter 1 from 'int' to 'double &'

- A reference variable cannot be bound to a temporary object

```
int getValue() {
    int tmp;
    return tmp;
}
int func(int &value);
void main() {
    func(getValue());
}
```

References (cont’d)

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void func(double &data) {
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    func(data);
    . . .
}
```

```
error C2664: 'func' : cannot convert parameter 1  from 'int' to 'double &'
```

- A reference variable cannot be bound to a temporary object

```
int getValue() {
    int tmp;
    return tmp;
}
int func(int &value);
void main() {
    func(getValue());
}
```

Only a **const reference variable** can bind to a temporary object
int func(const int &value)

```
error C2664: 'func' : cannot convert parameter 1
             from 'int' to 'int &'
```

Stricter Typing System

- In C, you can do

```
int *intPtr;
void *genericPtr;
genericPtr = intPtr;        // convert typed pointer to generic pointer
intPtr = genericPtr;        // generic to typed
```

Stricter Typing System

- In C, you can do

Giving up the advantages of strict type checking

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intPtr = (int *) genericPtr;  // explicit type cast
```

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```

- In C++, char literal is not treated as int as in C

```
void func(int i);
void func(char c);
```

overloaded functions

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void *genericPtr;
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intPtr = (int *) genericPtr; // explicit type cast  static_cast<int *>(genericPtr)
```

- In C++, char literal is not treated as int as in C

```
void func(int i);
void func(char c);
…
func('A') will invoke the second function
```

overloaded functions

Miscellaneous

- Scope resolution operator

```
static int x = 10;
void main() {
    int x = 5;
    cout << x << endl;

}
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```
Output:
5
10
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Output:
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- bool
  - A new type of boolean variable
  - The value can be true or false
  - #include <iomanip>
    using namespace std;
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#include <iomanip>
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…
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cout << boolalpha << x << endl;   // output true / false to the screen
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    cout << ::x << endl;
}
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Output:
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```
…
bool x = true;
cout << boolalpha << x << endl;   // output true / false to the screen
cin >> boolalpha >> x;            // input true / false through the keyboard
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Explicit Type Conversion

- C style type casting operator (type coercion)

```
int b = 200;
unsigned long a = (unsigned long int) b;
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  - ✶ **reinterpret_cast**: cast one type to whatever types you like, most dangerous, address is not changing if cast between pointers
  - ✶ **dynamic_cast**: for type-safe downcasting (checking at run time)

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int i; float f;
…
void *vp = &i;
float *fp = static_cast<float *>(vp);
i = static_cast<int>(f);
```

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*j = 10;
cout << "i=" << i << " *j=" << *j << endl;
```

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```
Output:
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weird, compiler makes **i** 0 directly

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struct X { int a[100]; } x;
…
int *xp = static_cast<int *>(&x);
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```
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struct X { int a[100]; } x;
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```

error C2440: ‘static_cast’ : 無法由 ‘**X ***’ 轉換為 ‘**int ***’, 指向的型別沒有相關; 轉換必須有 reinterpret_cast、C-Style 轉換或函式樣式轉換

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```
Output:
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weird, compiler makes **i** 0 directly

```
struct X { int a[100]; } x;
…
int *xp = reinterpret_cast<int *>(&x)
```

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  - typedef int IntArray[100]; // defines the alias name **IntArray**
    IntArray data; // is equivalent to int data[100];

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    Book book; // is equivalent to struct tagBook book;
  - typedef int IntArray[100]; // defines the alias name **IntArray**
    IntArray data; // is equivalent to int data[100];
  - typedef double (*FP)(int, double *); // defines the alias name **FP**
    FP fptr; // is equivalent to double (*fptr)(int, double *);