C++ Reference Card

Key

switch – keyword, reserved
"Hello!" – string
// comment – commented code
close() – library function
main – variable, identifier
variable – placeholder in syntax

```
if (expression) - syntax
   statement;
```

C++ Program Structure

```
// my first program in C++
#include <iostream.h>
int main ()
{
  cout << "Hello World!";
  return 0;
}

// single line comment
/* multi-line
   comment */
```

Identifiers

These are ANSI C++ reserved words and cannot be used as variable names.

asm, auto, bool, break, case, catch, char, class, const, const_cast, continue, default, delete, do, double, dynamic_cast, else, enum, explicit, extern, false, float, for, friend, goto, if, inline, int, long, mutable, namespace, new, operator, private, protected, public, register, reinterpret_cast, return, short, signed, sizeof, static, static_cast, struct, switch, template, this, throw, true, try, typedef, typeid, typename, union, unsigned, using, virtual, void, volatile, wchar_t

Data Types

Variable Declaration

```
special class size sign type name;
special: volatile
class: register, static, extern, auto
size: long, short, double
sign: signed, unsigned
type: int, float, char (required)
name: the variable name (required)
// example of variable declaration
extern short unsigned char AFlag;
```

TYPE	SIZE	RANGE
char	1	signed -128 to 127
		unsigned 0 to 255
short	2	signed -32,768 to 32,767
		unsigned 0 to 65,535
long	4	signed -2,147,483,648 to 2,147,483,647
		unsigned 0 - 4,294,967,295
int	varies depending on system	
float	4	3.4E +/- 38 (7 digits)
double	8	1.7E +/- 308 (15 digits)
long double	10	1.2E +/- 4,932 (19 digits)
bool	1	true or false
wchar_t	2	wide characters

Pointers

```
type *variable; // pointer to variable
type *func(); // function returns pointer
void * // generic pointer type
NULL;  // null pointer
*ptr;  // object pointed to by pointer
&obj   // address of object
```

Arrays

```
int arry[n];          // array of size n
int arry2d[n][m];     // 2d n x m array
int arry3d[i][j][k]; // 3d ixjxk array
```

Structures

```
struct name {
  type1 element1;
  type2 element2;
  ...
} object_name; // instance of name
name variable; // variable of type name
variable.element1; // ref. of element
variable->element1; // reference of
pointed to structure
```

Operators

priority/**operator**/**desc**/ASSOCIATIVITY

1 :: **scope** LEFT

2 **()** **parenthesis** LEFT
[ ] **brackets** LEFT
-> **pointer reference** LEFT
. **structure member access** LEFT
sizeof **returns memory size** LEFT

3 **++** **increment** RIGHT
-- **decrement** RIGHT
~ **complement to one (bitwise)** RIGHT
! **unary NOT** RIGHT
& **reference (pointers)** RIGHT
*** **dereference** RIGHT
(type) **type casting** RIGHT
+ - **unary less sign** RIGHT

4 ***** **multiply** LEFT
/ **divide** LEFT
% **modulus** LEFT

5 **+** **addition** LEFT
- **subtraction** LEFT

6 **<<** **bitwise shift left** LEFT
>> **bitwise shift right** LEFT

7 **<** **less than** LEFT
<= **less than or equal** LEFT
> **greater than** LEFT
>= **greater than or equal** LEFT

8 **==** **equal** LEFT
!= **not equal** LEFT

9 **&** **bitwise AND** LEFT
^ **bitwise NOT** LEFT
| **bitwise OR** LEFT

10 **&&** **logical AND** LEFT
|| **logical OR** LEFT

11 **? :** **conditional** RIGHT

12 **=** **assignment**
+= **add/assign**
-= **subtract/assign**
***=** **multiply/assign**
/= **divide/assign**
%= **modulus/assign**
>>= **bitwise shift right/assign**
<<= **bitwise shift left/assign**
&= **bitwise AND/assign**
^= **bitwise NOT/assign**
|= **bitwise OR/assign**

13 **,** **comma**

Initialization of Variables

```
type id;        // declaration
type id,id,id; // multiple declaration
type *id;       // pointer declaration
type id = value; // declare with assign
type *id = value; // pointer with assign
id = value; // assignment
```

Examples

```
// single character in single quotes
char c='A';
// string in double quotes, ptr to string
char *str = "Hello";
int i = 1022;
float f = 4.0E10; // 4^10
int ary[2] = {1,2} // array of ints
const int a = 45; // constant declaration
struct products { // declaration
  char name [30];
  float price;
} ;
products apple; // create instance
apple.name = "Macintosh"; // assignment
apple.price = 0.45;
products *pApple; // pointer to struct
pApple->name = "Granny Smith";
pApple->price = 0.35; // assignment
```

Exceptions

```
try {
  // code to be tried... if statements
  statements; // fail, exception is set
  throw exception;
}
catch (type exception) {
  // code in case of exception
  statements;
}
```

User Defined DataTypes

```
typedef existingtype newtypename;
typedef unsigned int WORD;
enum name{val1, val2, ...} obj name;
enum days_t {MON,WED,FRI} days;
union model_name {
  type1 element1;
  type2 element2; ...
} object_name;
union mytypes_t {
  char c;
  int i;
} mytypes;
struct packed {  // bit fields
  unsigned int flagA:1; // flagA is 1 bit
  unsigned int flagB:3; // flagB is 3 bit
}
```

Preprocessor Directives

```
#define ID value // replaces ID with
//value for each occurrence in the code
#undef ID  // reverse of #define
#ifdef ID  //executes code if ID defined
#ifndef ID // opposite of #ifdef
#if expr   // executes if expr is true
#else      // else
#elif      // else  if
#endif     // ends if block
#line number "filename"
// #line controls what line number and
// filename appear when a compiler error
// occurs
#error msg //reports msg on cmpl. error
#include "file" // inserts file into code
                // during compilation
#pragma //passes parameters to compiler
```

Control Structures

Decision (if-else)

```
if (condition) {
  statements;
}
else if (condition) {
  statements;
}
else {
  statements;
}
if (x == 3) // curly braces not needed
  flag = 1; // when if statement is
else          // followed by only one
  flag = 0; // statement
```

Repetition (while)

```
while (expression) { // loop until
  statements;       // expression is false
}
```

Repetition (do-while)

```
do {           // perform the statements
  statements; // as long as condition
} while (condition); // is true
```

Repetition (for)

init - initial value for loop control variable
condition - stay in the loop as long as condition is true
increment - change the loop control variable

```
for(init; condition; increment) {
  statements;
}
```

Bifurcation (break, continue, goto, exit)

```
break; // ends a loop
continue; // stops executing statements
// in current iteration of loop cont-
// inues executing on next iteration
label:
goto label; // execution continues at
// label
exit(retcode); // exits program
```

Selection (switch)

```
switch (variable) {
  case constant1: // chars, ints
    statements;
    break; // needed to end flow
  case constant2:
    statements;
    break;
  default:
    statements; // default statements
}
```

Console Input/Output

[See ***File I/O*** *on reverse for more about streams*]

C Style Console I/O

```
stdin - standard input stream
stdout - standard output stream
stderr - standard error stream
// print to screen with formatting
printf("format",  arg1,arg2,...);
printf("nums: %d, %f, %c", 1,5.6,'C');
// print to string s
sprintf(s,"format", arg1, arg2,...);
sprintf(s,"This is string # %i",2);
// read data from keyboard into
// name1,name2,...
scanf("format",&name1,&name2, ...);
scanf("%d,%f",var1,var2); // read nums
// read from string s
sscanf("format",&name1,&name2, ...);
sscanf(s,"%i,%c",var1,var2);
```

C Style I/O Formatting

```
%d, %i  integer
%c      single character
%f      double (float)
%o      octal
%p      pointer
%u      unsigned
%s      char string
%e, %E  exponential
%x, %X  hexadecimal
%n      number of chars written
%g, %G  same as f for e,E
```

C++ console I/O

```
cout<< console out, printing to screen
cin>> console in, reading from keyboard
cerr<< console error
clog<< console log
cout<<"Please enter an integer: ";
cin>>i;
cout<<"num1:  "<<i<<"\n"<<endl;
```

Control Characters

```
\b backspace   \f form feed  \r return
\' apostrophe  \n newline    \t tab
\nnn character #nnn (octal)  \" quote
\NN character #NN (hexadecimal)
```

Character Strings

The string "Hello" is actually composed of 6 characters and is stored in memory as follows:

Char	H	e	l	l	o	\0
Index	0	1	2	3	4	5

\0 (backslash zero) is the null terminator character and determines the end of the string. A string is an array of characters. Arrays in C and C++ start at zero.

```
str = "Hello";
str[2] = 'e';  // string is now 'Heelo'
```

common <string.h> functions:
strcat(*s1,s2*) **strchr**(*s1,c*) **strcmp**(*s1,s2*)
strcpy(*s2,s1*) **strlen**(*s1*) **strncpy**(*s2,s1,n*)
strstr(*s1,s2*)

Functions

In C, functions must be prototyped before the main function, and defined after the **main** function. In C++, functions may, but do not need to be, prototyped. C++ functions must be defined before the location where they are called from.

```
// function declaration
type name(arg1, arg2, ...) {
  statement1;
  statement2;
  ...
}
```

type – return type of the function
name – name by which the function is called
arg1, arg2 – parameters to the function
statement – statements inside the function

```
// example function declaration
// return type int
int add(int a, int b) { // parms
  int r;                // declaration
  r = a + b;            // add nums
  return r;             // return value
}
// function call
num = add(1,2);
```

Passing Parameters

Pass by Value

```
function(int var); // passed by value
```

Variable is passed into the function and can be changed, but changes are not passed back.

Pass by Constant Value

```
function(const int var);
```

Variable is passed into the function but cannot be changed.

Pass by Reference

```
function(int &var); // pass by reference
```

Variable is passed into the function and can be changed, changes are passed back.

Pass by Constant Reference

```
function(const int &var);
```

Variable cannot be changed in the function.

Passing an Array by Reference

It's a waste of memory to pass arrays and structures by value, instead pass by reference.

```
int array[1]; // array declaration
ret = aryfunc(&array); // function call
int aryfunc(int *array[1]) {
  array[0] = 2;          // function
  return 2;              // declaration
}
```

Default Parameter Values

```
int add(int a, int b=2) {
  int r;
  r=a+b;     // b is always 2
  return (r);
}
```

Overloading Functions

Functions can have the same name, and same number of parameters as long as the parameters of are different types

```
// takes and returns integers
int divide (int a, int b)
{ return (a/b); }
// takes and returns floats
float divide (float a, float b)
{ return (a/b); }
divide(10,2); // returns 5
divide(10,3); // returns 3.33333333
```

Recursion

Functions can call themselves

```
long factorial (long n) {
  if (n > 1)
    return (n * factorial (n-1));
  else
    return (1);
}
```

Prototyping

Functions can be prototyped so they can be used after being declared in any order

```
// prototyped functions can be used
// anywhere in the program
#include   <iostream.h>
void odd (int a);
void even (int a);
int main () { ... }
```

Namespaces

Namespaces allow global identifiers under a name

```
// simple namespace
namespace identifier {
  namespace-body;
}
//  example  namespace
namespace first {int var = 5;}
namespace second {double var = 3.1416;}
int main () {
  cout << first::var << endl;
  cout << second::var << endl;
  return 0;
}
```

using namespace allows for the current nesting level to use the appropriate namespace

```
using namespace identifier;
// example using namespace
namespace first {int var = 5;}
namespace second {double var = 3.1416;}
int main () {
  using namespace second;
  cout << var << endl;
  cout << (var*2) << endl;
  return 0;
}
```

Class Reference

Class Syntax

```
class classname {
  public:
    classname(parms); // constructor
    ~classname();     // destructor
    member1;
    member2;
  protected:
    member3;
    ...
  private:
    member4;
} objectname;
// constructor (initializes variables)
classname::classname(parms) {
}
// destructor (deletes variables)
classname::~classname() {
}
```

public members are accessible from anywhere where the class is visible
protected members are only accessible from members of the same class or of a friend class
private members are accessible from members of the same class, members of the derived classes and a friend class
constructors may be overloaded just like any other function. define two identical constructors with difference parameter lists

Class Example

```
class CSquare { // class declaration
  public:
    void Init(float h, float w);
    float GetArea(); // functions
  private: // available only to CSquare
    float h,w;
}  // implementations of functions
void CSquare::Init(float hi, float wi){
  h = hi; w = wi;
}
float CSquare::GetArea() {
  return (h*w);
}
// example declaration and usage
CSquare theSquare;
theSquare.Init(8,5);
area = theSquare.GetArea();
// or using a pointer to the class
CSquare *theSquare;
theSquare->Init(8,5);
 area = theSquare->GetArea();
```

Overloading Operators

Like functions, operators can be overloaded.

Imagine you have a class that defines a square and you create two instances of the class. You can add the two objects together.

```
class CSquare { // declare a class
  public: // functions
    void Init(float h, float w);
    float GetArea();
    CSquare operator + (CSquare);
  private:   // overload the '+' operator
    float h,w;
} // function implementations
void CSquare::Init(float hi, float wi){
  h = hi; w = wi;
}
float CSquare::GetArea() {
  return (h*w);
}// implementation of overloaded operator
CSquare CSquare::operator+ (CSquare cs) {
  CSquare temp; // create CSquare object
  temp.h = h + cs.h; // add h and w to
  temp.w = w + cs.w; // temp object
  return (temp);
}
// object declaration and usage
CSquare sqr1, sqr2, sqr3;
sqr1.Init(3,4); // initialize objects
sqr2.Init(2,3);
sqr3 = sqr1 + sqr2; // object sqr3 is now
(5,7)
```

Advanced Class Syntax

Static Keyword

static variables are the same throughout all instances of a class.

```
static int n; // declaration
CDummy::n;    // reference
```

Virtual Members

Classes may have virtual members. If the function is redefined in an inherited class, the parent must have the word **virtual** in front of the function definition

This keyword

The **this** keyword refers to the memory location of the current object.

```
int func(this); // passes pointer to
                // current object
```

Class TypeCasting

```
reinterpret_cast <newtype>(expression);
   dynamic_cast <newtype>(expression);
    static_cast <newtype>(expression);
     const_cast <newtype>(expression);
```

Expression Type

The type of an expression can be found using **typeid**. **typeid** returns a type.

```
typeid(expression);
```

Inheritance

Functions from a class can be inherited and reused in other classes. **Multiple inheritance** is possible.

```
class CPoly { //create base polygon class
  protected:
    int width, height;
  public:
    void SetValues(int a, int b)
      { width=a; height=b;}
};
class COutput { // create base output
  public:       // class
    void Output(int i);
};
void COutput::Output (int i) {
  cout << i << endl;
}
// CRect inherits SetValues from Cpoly
// and inherits Output from COutput
class CRect: public CPoly, public COutput
{
  public:
    int area(void)
      { return (width * height); }
};
// CTri inherits SetValues from CPoly
class CTri: public CPoly {
  public:
    int area(void)
      { return (width * height / 2); }
};
void main () {
  CRect rect; // declare objects
  CTri tri;
  rect.SetValues (2,9);
  tri.SetValues (2,9);
  rect.Output(rect.area());
  cout<<tri.area()<<endl;
}
```

Templates

Templates allow functions and classes to be reused without overloading them

```
template <class id> function;
template <typename id> function;
// --------- function example ---------
template <class T>
T GetMax (T a, T b) {
  return (a>b?a:b); // return the larger
}
void main () {
  int a=9, b=2, c;
  float x=5.3, y=3.2, z;
  c=GetMax(a,b);
  z=GetMax(x,y);
}
// ---------- class example ----------
template <class T>
class CPair {
    T x,y;
  public:
    Pair(T a, T b){
      x=a; y=b; }
    T GetMax();
};
template <class T>
T Pair<T>::GetMax()
{ // implementation of GetMax function
  T ret; // return a template
  ret = x>y?x:y; // return larger
  return ret;
}
int main () {
  Pair <int> theMax (80, 45);
  cout << theMax.GetMax();
  return 0;
}
```

Friend Classes/Functions

Friend Class Example

```
class CSquare; // define CSquare
class CRectangle {
  int width, height;
  public:
    void convert (CSquare a);
};
class CSquare { // we want to use the
  private:      // convert function in
    int side;   // the CSquare class, so
  public:       // use the friend keyword
    void set_side (int a) { side=a; }
    friend class CRectangle;
};
void CRectangle::convert (CSquare a) {
  width = a.side;
  height = a.side;
}
// declaration and usage
CSquare sqr;
CRectangle rect; // convert can be
sqr.set_side(4); // used by the
rect.convert(sqr); // rectangle class
```

Friend Functions

A friend function has the keyword **friend** in front of it. If it is declared inside a class, that function can be called without reference from an object. An object may be passed to it.

```
/* change can be used anywhere and can
have a CRect object passed in */
// this example defined inside a class
friend CRect change(CRect);
CRectangle recta, rectb; // declaration
 rectb = change(recta); // usage
```

File I/O

```
#include <fstream.h> // read/write file
#include <ofstream.h> // write file
#include <ifstream.h> // read file
```

File I/O is done from the **fstream**, **ofstream**, and **ifstream** classes.

File Handles

A file must have a file handle (pointer to the file) to access the file.

```
ifstream infile; // create handle called
// infile to read from a file
ofstream outfile; // handle for writing
fstream f; // handle for read/write
```

Opening Files

After declaring a file handle, the following syntax can be used to open the file

```
void open(const char *fname, ios::mode);
```

fname should be a string, specifying an absolute or relative path, including filename. **ios::***mode* can be any number of the following and repeat:

in Open file for reading
out Open file for writing
ate Initial position: end of file
app Every output is appended at the end of file
trunc If the file already existed it is erased
binary Binary mode

```
ifstream f; // open input file example
f.open("input.txt", ios::in);
ofstream f; // open for writing in binary
f.open("out.txt", ios::out | ios::binary
| ios::app);
```

Closing a File

A file can be closed by calling the handle's close function

```
f.close();
```

Writing To a File (Text Mode)

The operator **<<** can be used to write to a file. Like **cout**, a stream can be opened to a device. For file writing, the device is not the console, it is the file. **cout** is replaced with the file handle.

```
ofstream f; // create file handle
f.open("output.txt") // open file
f <<"Hello World\n"<<a<<b<<c<<endl;
```

Reading From a File (Text Mode)

The operator **>>** can be used to read from a file. It works similar to cin. Fields are seperated in the file by spaces.

```
ifstream f; // create file handle
f.open("input.txt"); // open file
while (!f.eof()) // end of file test
  f >>a>>b>>c; // read into a,b,c
```

I/O State Flags

Flags are set if errors or other conditions occur. The following functions are members of the file object

handle.**bad()** returns true if a failure occurs in reading or writing
handle.**fail()** returns true for same cases as bad() plus if formatting errors occur
handle.**eof()** returns true if the end of the file reached when reading
handle.**good()** returns false if any of the above were true

Stream Pointers

handle.**tellg()** returns pointer to current location when reading a file
handle.**tellp()** returns pointer to current location when writing a file

```
// seek a position in reading a file
handle.seekg(position);
handle.seekg(offset, direction);
// seek a position in writing a file
handle.seekp(position);
handle.seekp(offset, direction);
```

direction can be one of the following
ios::beg beginning of the stream
ios::cur current position of the stream pointer
ios::end end of the stream

Binary Files

buffer is a location to store the characters.
numbytes is the number of bytes to written or read.

```
write(char *buffer, numbytes);
read(char *buffer, numbytes);
```

Output Formatting

```
streamclass f;  // declare file handle

// set output flags
f.flags(ios_base::flag)
```

possible *flags*

dec **fixed** **hex** **oct**
scientific **internal** **left** **right**
uppercase **boolalpha** **showbase** **showpoint**
showpos **skipws** **unitbuf**
adjustfield left | right | internal
basefield dec | oct | hex
floatfield scientific | fixed

```
f.fill() get fill character
f.fill(ch) set fill character ch
f.precision(numdigits) sets the precision for
floating point numbers to numdigits
f.put(c) put a single char into output stream
f.setf(flag) sets a flag
f.setf(flag, mask) sets a flag w/value
f.width() returns the current number of
characters to be written
f.width(num) sets the number of chars to be
written
```

ACSII Chart

Dec	Char	Dec	Char	Dec	Char	Dec	Char
0	NUL	64	@	128	Ç	192	└
1	SOH	65	A	129	ü	193	┴
2	STX	66	B	130	é	194	┬
3	ETX	67	C	131	â	195	├
4	EOT	68	D	132	ä	196	─
5	ENQ	69	E	133	à	197	┼
6	ACK	70	F	134	å	198	╞
7	BEL	71	G	135	ç	199	╟
8	BS	72	H	136	ê	200	╚
9	TAB	73	I	137	ë	201	╔
10	LF	74	J	138	è	202	╩
11	VTB	75	K	139	ï	203	╦
12	FF	76	L	140	î	204	╠
13	CR	77	M	141	ì	205	═
14	SO	78	N	142	Ä	206	╬
15	SI	79	O	143	Å	207	╧
16	DLE	80	P	144	É	208	╨
17	DC1	81	Q	145	æ	209	╤
18	DC2	82	R	146	Æ	210	╥
19	DC3	83	S	147	ô	211	╙
20	DC4	84	T	148	ö	212	╘
21	NAK	85	U	149	ò	213	╒
22	SYN	86	V	150	û	214	╓
23	ETB	87	W	151	ù	215	╫
24	CAN	88	X	152	ÿ	216	╪
25	EM	89	Y	153	Ö	217	┘
26	SUB	90	Z	154	U	218	┌
27	ESC	91	[	155	¢	219	█
28	FS	92	\	156	£	220	▄
29	GS	93	]	157	¥	221	▌
30	RS	94	^	158	?	222	▐
31	US	95	_	159	ƒ	223	▀
32		96	`	160	á	224	α
33	!	97		161	í	225	ß
34	"	98	a	162	ó	226	Γ
35	#	99		163	ú	227	π
36	$	100	b	164	ñ	228	Σ
37	%	101		165	Ñ	229	σ
38	&	102	c	166	ª	230	µ
39	'	103		167	º	231	τ
40	(	104	d	168	¿	232	Φ
41	)	105		169	?	233	Θ
42	*	106	e	170	¬	234	Ω
43	+	107		171	½	235	δ
44	,	108	f	172	¼	236	∞
45	-	109		173	¡	237	φ
46	.	110	g	174	«	238	ε
47	/	111		175	»	239	∩
			h				≡
			i				±
			j				≥
			k				≤
			l				?
			m				÷
			n				≈
			o				°
48	0	112	p	176	?	240	?
49	1	113	q	177	▒	241	·
50	2	114	r	178	▓	242	√
51	3	115	s	179	|	243	?
52	4	116	t	180	┤	244	■
53	5	117	u	181	╡	245	
54	6	118	v	182	╢	246	
55	7	119	w	183	╖	247	
56	8	120	x	184	╕	248	

Dynamic Memory

Memory can be allocated and deallocated

```
// allocate memory (C++ only)
pointer = new type [];
int *ptr;          // declare a pointer
ptr = new int;  // create a new instance
ptr = new int [5]; // new array of ints
// deallocate memory (C++ only)
delete [] pointer;
delete ptr;    // delete a single int
delete [] ptr // delete array
// allocate memory (C or C++)
void * malloc (nbytes); // nbytes=size
char *buffer;  // declare a buffer

// allocate 10 bytes to the buffer
buffer = (char *)malloc(10);
// allocate memory (C or C++)
// nelements = number elements
// size = size of each element
void * malloc (nelements, size);
int *nums;  // declare a buffer
// allocate 5 sets of ints
nums = (char *)calloc(5,sizeof(int));
// reallocate memory (C or C++)
void * realloc (*ptr, size);
// delete memory (C or C++)
  void free (*ptr);
```

ANSI C++ Library Files

The following files are part of the ANSI C++ standard and should work in most compilers.

```
<algorithm.h> <bitset.h> <deque.h>
<exception.h> <fstream.h> <functional.h>
<iomanip.h> <ios.h> <iosfwd.h>
<iostream.h> <istream.h> <iterator.h>
<limits.h> <list.h> <locale.h> <map.h>
<memory.h> <new.h> <numeric.h>
<ostream.h> <queue.h> <set.h> <sstream.h>
<stack.h> <stdexcept.h> <streambuf.h>
<string.h> <typeinfo.h> <utility.h>
<valarray.h> <vector.h>
```