Libraries

Computational assistants

Functions

- Previous examples
  - Programmer-defined functions
    - **`main()`**
    - **`ApiMain()`**
  - Library-defined functions
    - **`cin.get()`**
    - **`string`** member functions **`size()`**
    - **`RectangleShape`** member function **`Draw()`**
    - **`SimpleWindow`** member function **`Open()`**
- Advice
  - Don’t reinvent the wheel! There are lots of libraries out there

Terminology

- A function is invoked by a *function call / function invocation*

```
y = f(a);
```

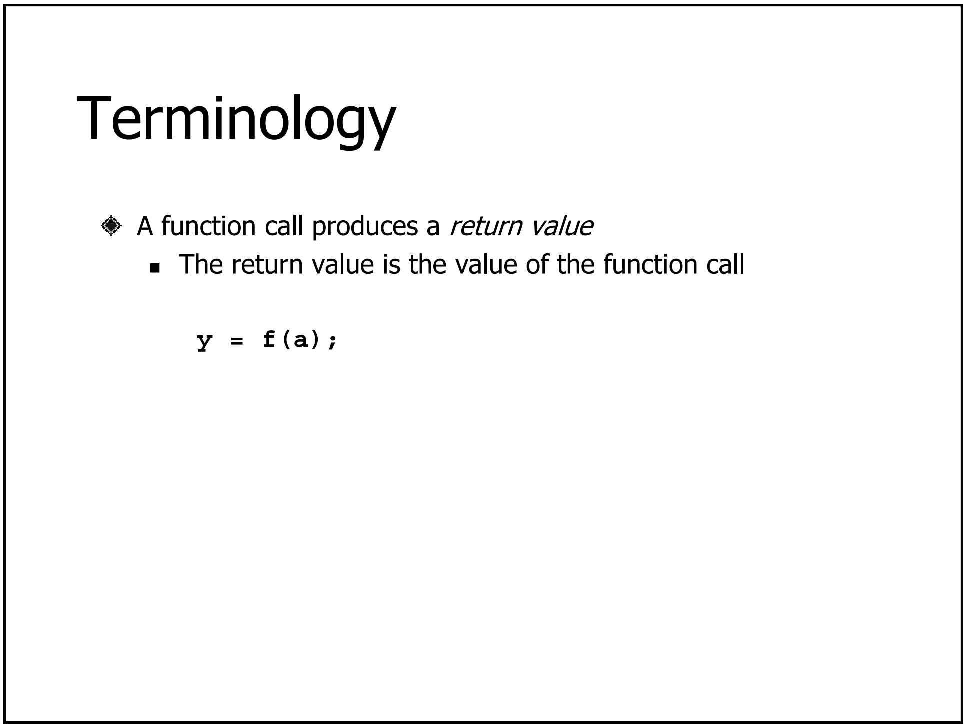
Terminology

- A function call specifies
  - The *function name*
    - The name indicates what function is to be called

```
y = f(a);
```

  - The *actual parameters* to be used in the invocation
    - The values are the information that the called function requires from the invoking function to do its task

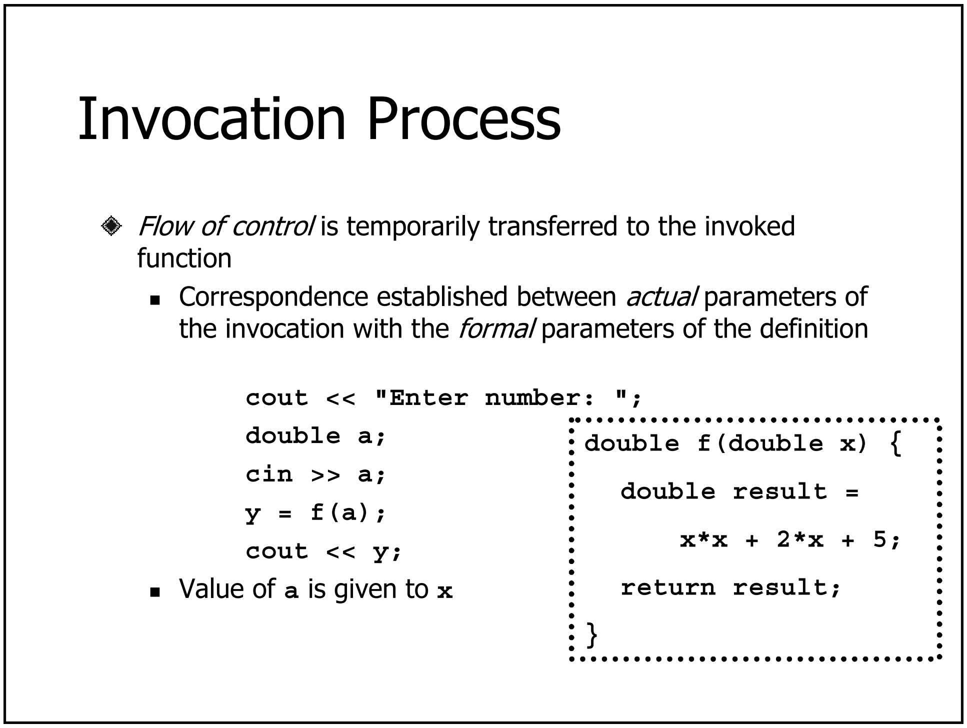
```
y = f(a);
```



Terminology

- A function call produces a *return value*
  - The return value is the value of the function call

```
y = f(a);
```



Invocation Process

- *Flow of control* is temporarily transferred to the invoked function
  - Correspondence established between *actual* parameters of the invocation with the *formal* parameters of the definition

```
cout << "Enter number: ";
double a;
cin >> a;
y = f(a);
cout << y;
```

```
double f(double x) {
   double result =
       x*x + 2*x + 5;
   return result;
}
```

  - Value of `a` is given to `x`

Invocation Process

- ◈ *Flow of control* is temporarily transferred to the invoked function
  - Local objects are also maintained in the invocation's *activation record.* Even main() has a record

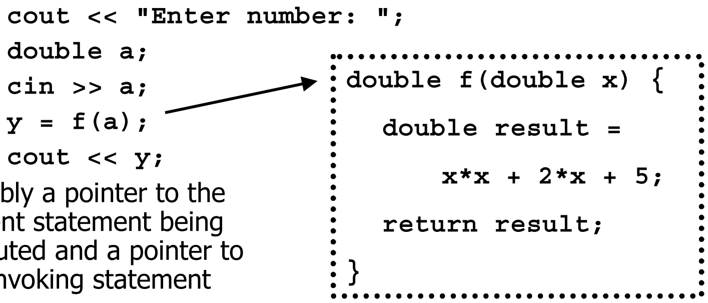
```
cout << "Enter number: ";
double a;
cin >> a;
y = f(a);
cout << y;
```

```
double f(double x) {
   double result =
       x*x + 2*x + 5;
   return result;
}
```

  - Activation record is large enough to store values associated with each object that is defined by the function

Invocation Process

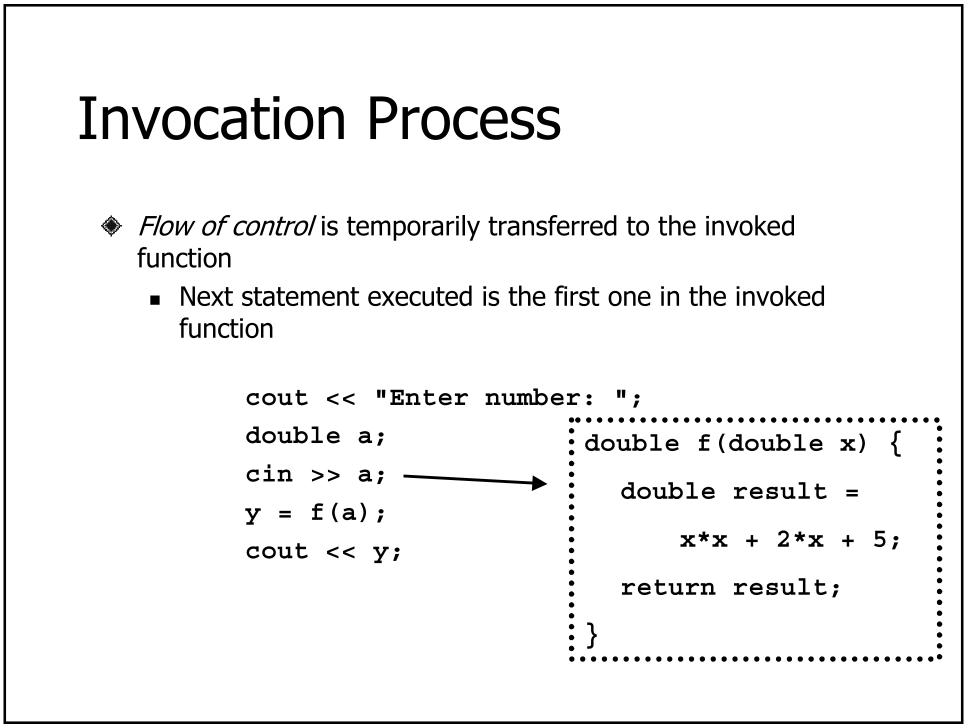
- ◈ *Flow of control* is temporarily transferred to the invoked function
  - Other information may also be maintained in the invocation's *activation record*



```
cout << "Enter number: ";
double a;
cin >> a;
y = f(a);
cout << y;
```

```
double f(double x) {
   double result =
       x*x + 2*x + 5;
   return result;
}
```

  - Possibly a pointer to the current statement being executed and a pointer to the invoking statement

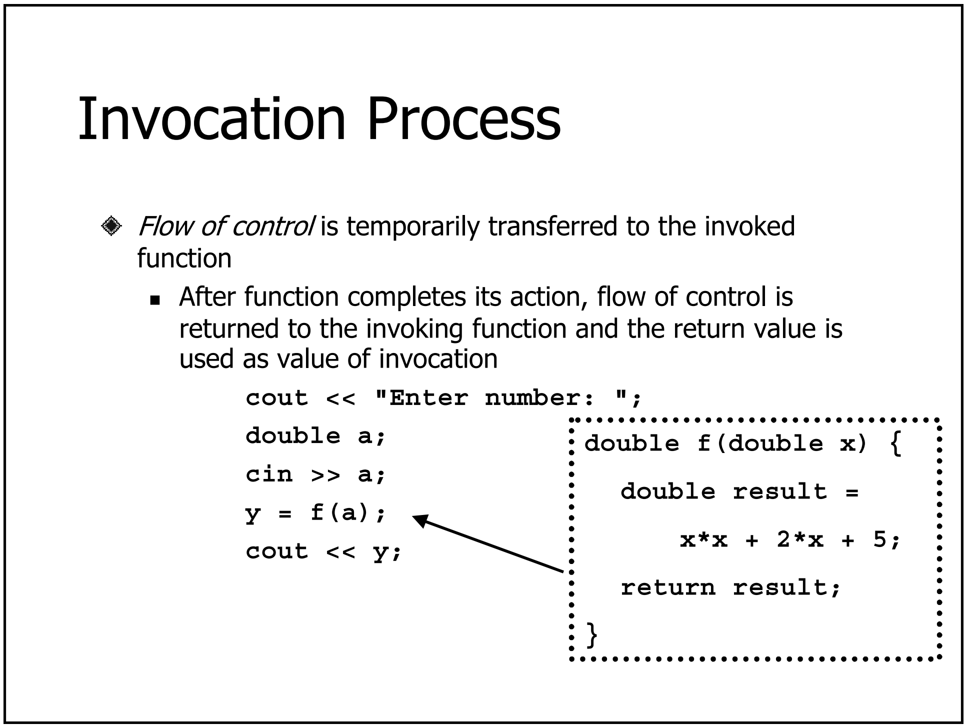


Invocation Process

- *Flow of control* is temporarily transferred to the invoked function
  - Next statement executed is the first one in the invoked function

```
cout << "Enter number: ";
double a;
cin >> a;
y = f(a);
cout << y;
```

```
double f(double x) {
   double result =
        x*x + 2*x + 5;
   return result;
}
```



Invocation Process

- *Flow of control* is temporarily transferred to the invoked function
  - After function completes its action, flow of control is returned to the invoking function and the return value is used as value of invocation

```
cout << "Enter number: ";
double a;
cin >> a;
y = f(a);
cout << y;
```

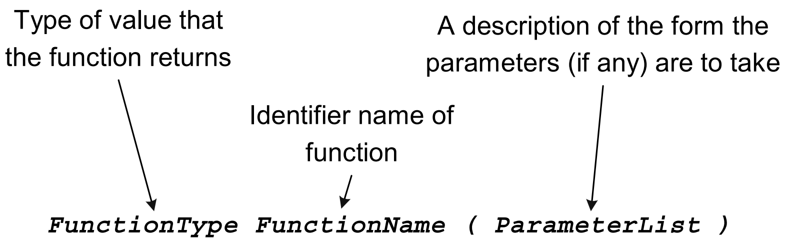
```
double f(double x) {
   double result =
        x*x + 2*x + 5;
   return result;
}
```

Execution Process

- Function body of invoked function is executed
- Flow of control then returns to the invocation statement
- The return value of the invoked function is used as the value of the invocation expression

Function Prototypes

- Before a function can appear in an invocation its interface must be specified
  - *Prototype* or complete definition



Type of value that the function returns

Identifier name of function

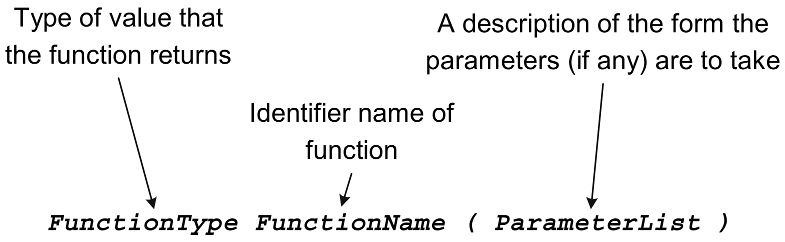
A description of the form the parameters (if any) are to take

```
FunctionType FunctionName ( ParameterList )
```

```
int Max(int a, int b)
```

Function Prototypes

- Before a function can appear in an invocation its interface must be specified
  - Prototypes are normally kept in library header files



Type of value that the function returns

A description of the form the parameters (if any) are to take

Identifier name of function

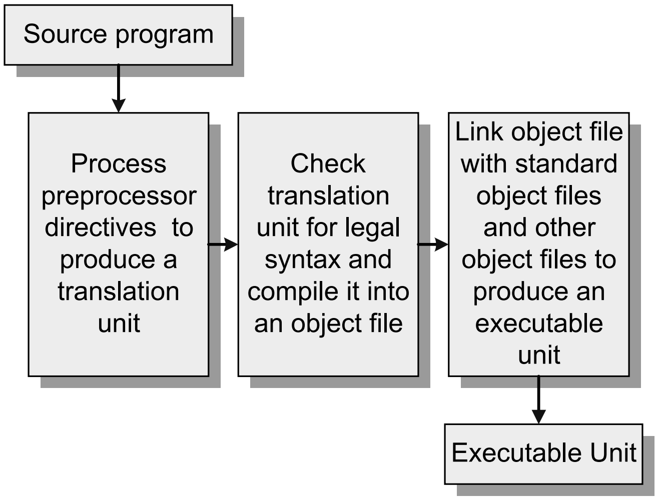
FunctionType FunctionName (ParameterList)

```
int Max(int a, int b)
```

Libraries

- Library
  - Collection of functions, classes, and objects grouped by commonality of purpose
  - Include statement provides access to the names and descriptions of the library components
  - Linker connects program to actual library definitions
- Previous examples
  - String: STL’s string class
  - Graphics: EzWindows

Basic Translation Process



Source program

Process preprocessor directives to produce a translation unit

Check translation unit for legal syntax and compile it into an object file

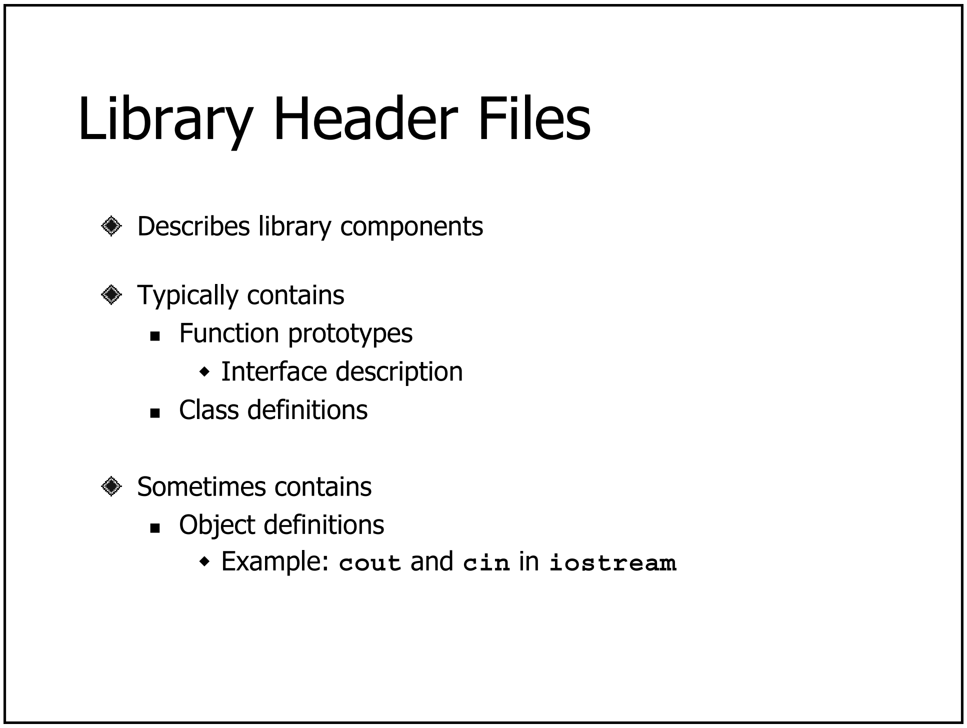
Link object file with standard object files and other object files to produce an executable unit

Executable Unit

Some Standard Libraries

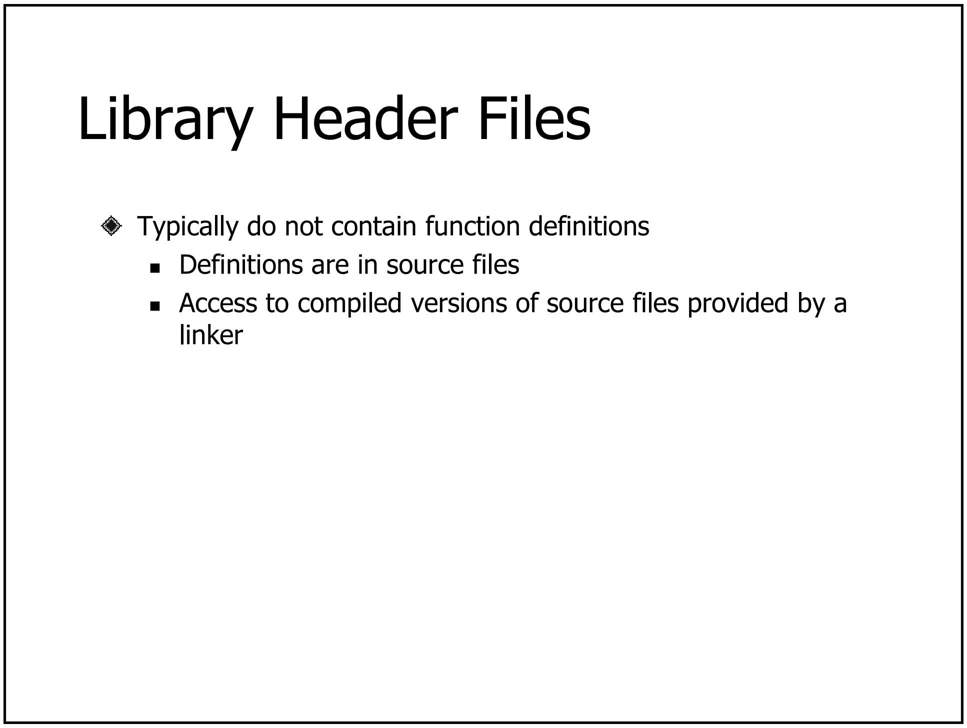
- fstream
  - File stream processing
- assert
  - C-based library for assertion processing
- iomanip
  - Formatted input/output (I/O) requests
- ctype
  - C-based library for character manipulations
- math
  - C-based library for trigonometric and logarithmic functions

- Note
  - C++ has many other libraries



Library Header Files

- Describes library components
- Typically contains
  - Function prototypes
    - Interface description
  - Class definitions
- Sometimes contains
  - Object definitions
    - Example: `cout` and `cin` in `iostream`

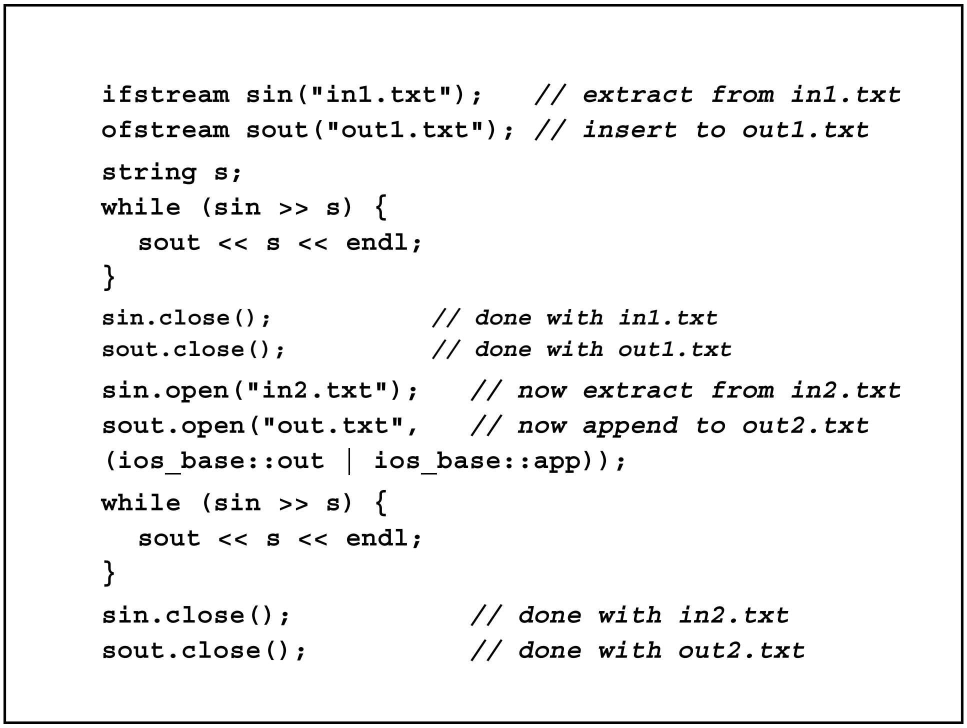


Library Header Files

- Typically do not contain function definitions
  - Definitions are in source files
  - Access to compiled versions of source files provided by a linker

```
#include <iostream>
#include <cmath>        Library header files
using namespace std;
int main() {
  cout << "Enter Quadratic coefficients: ";
  double a, b, c;
  cin >> a >> b >> c;                         Invocation
  if ( (a != 0) && (b*b - 4*a*c > 0) ) {
      double radical = sqrt(b*b - 4*a*c);
      double root1 = (-b + radical) / (2*a);
      double root2 = (-b - radical) / (2*a);
      cout << "Roots: " << root1 << " " << root2;
  }
  else {
      cout << "Does not have two real roots";
  }
  return 0;
}
```

```
#include <iostream>
#include <fstream>     // file stream library
using namespace std;
int main() {
  ifstream fin("mydata.txt");
  int ValuesProcessed = 0;
  float ValueSum = 0;
  float Value;
  while (fin >> Value) {
      ValueSum += Value;
      ++ValuesProcessed;
  }
  if (ValuesProcessed > 0) {
      ofstream fout("average.txt");
      float Average = ValueSum / ValuesProcessed;
      fout << "Average: " << Average << endl;
      return 0;
  }
  else {
      cerr << "No list to average" << endl;
      return 1;
  }
}
```



```
ifstream sin("in1.txt");   // extract from in1.txt
ofstream sout("out1.txt"); // insert to out1.txt
string s;
while (sin >> s) {
  sout << s << endl;
}
sin.close();           // done with in1.txt
sout.close();          // done with out1.txt
sin.open("in2.txt");   // now extract from in2.txt
sout.open("out.txt",   // now append to out2.txt
(ios_base::out | ios_base::app));
while (sin >> s) {
  sout << s << endl;
}
sin.close();           // done with in2.txt
sout.close();          // done with out2.txt
```